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COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 15-1

PD 98-1620 **08/15/15**

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)

OCE - MARINE GEOLOGY AND GEOPHYSICS

FOR NSF USE ONLY

NSF PROPOSAL NUMBER

1558647

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
08/13/2015	2	06040000 OCE	1620	062761671	03/04/2017 1:16pm S

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)

426004813

SHOW PREVIOUS AWARD NO. IF THIS IS
☐ A RENEWAL
☐ AN ACCOMPLISHMENT-BASED RENEWAL

IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE

University of Iowa

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE

University of Iowa
2 Gilmore Hall
Iowa City, IA. 522421320

AWARDEE ORGANIZATION CODE (IF KNOWN)

0018929000

NAME OF PRIMARY PLACE OF PERF

University of Iowa

ADDRESS OF PRIMARY PLACE OF PERF, INCLUDING 9 DIGIT ZIP CODE

University of Iowa

IA ,522421320 ,US.

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
☐ SMALL BUSINESS ☐ MINORITY BUSINESS ☐ FOR-PROFIT ORGANIZATION ☐ WOMAN-OWNED BUSINESS

☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **Collaborative Research: Subduction Initiation and development of the nascent Izu-Bonin-Mariana arc: A Petrologic and Geochemical Investigation of IODP Expedition 352 whole rocks an**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ 100,997	24 months	06/01/16	

THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

☐ BEGINNING INVESTIGATOR (GPG I.G.2)
☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C.1.e)
☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
☐ HISTORIC PLACES (GPG II.C.2.j)
☐ VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date ________
PHS Animal Welfare Assurance Number ________
☒ FUNDING MECHANISM **Research - other than RAPID or EAGER**

☐ HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number ________
Exemption Subsection ________ or IRB App. Date ________
☒ INTERNATIONAL ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j)

AS

☒ COLLABORATIVE STATUS
A collaborative proposal from multiple organizations (GPG II.D.4.b)

PI/PD DEPARTMENT

Dept. of Earth & Environmental Sciences

PI/PD POSTAL ADDRESS

115 Trowbridge Hall

Iowa City, IA 522421379
United States

PI/PD FAX NUMBER

319-335-1821

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Email Address
PI/PD NAME Mark K Reagan	PhD	1987	319-335-1802	mark-reagan@uiowa.edu
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

CERTIFICATION PAGE

Certification for Authorized Organizational Representative (or Equivalent) or Individual Applicant

By electronically signing and submitting this proposal, the Authorized Organizational Representative (AOR) or Individual Applicant is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding conflict of interest (when applicable), drug-free workplace, debarment and suspension, lobbying activities (see below), nondiscrimination, flood hazard insurance (when applicable), responsible conduct of research, organizational support, Federal tax obligations, unpaid Federal tax liability, and criminal convictions as set forth in the NSF Proposal & Award Policies & Procedures Guide,Part I: the Grant Proposal Guide (GPG). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U.S. Code, Title 18, Section 1001).

Certification Regarding Conflict of Interest

The AOR is required to complete certifications stating that the organization has implemented and is enforcing a written policy on conflicts of interest (COI), consistent with the provisions of AAG Chapter IV.A.; that, to the best of his/her knowledge, all financial disclosures required by the conflict of interest policy were made; and that conflicts of interest, if any, were, or prior to the organization's expenditure of any funds under the award, will be, satisfactorily managed, reduced or eliminated in accordance with the organization's conflict of interest policy. Conflicts that cannot be satisfactorily managed, reduced or eliminated and research that proceeds without the imposition of conditions or restrictions when a conflict of interest exists, must be disclosed to NSF via use of the Notifications and Requests Module in FastLane.

Drug Free Work Place Certification

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent), is providing the Drug Free Work Place Certification contained in Exhibit II-3 of the Grant Proposal Guide.

Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) or Individual Applicant is providing the Debarment and Suspension Certification contained in Exhibit II-4 of the Grant Proposal Guide.

Certification Regarding Lobbying

This certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ''Disclosure of Lobbying Activities,'' in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

Certification Regarding Nondiscrimination

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) is providing the Certification Regarding Nondiscrimination contained in Exhibit II-6 of the Grant Proposal Guide.

Certification Regarding Flood Hazard Insurance

Two sections of the National Flood Insurance Act of 1968 (42 USC §4012a and §4106) bar Federal agencies from giving financial assistance for acquisition or construction purposes in any area identified by the Federal Emergency Management Agency (FEMA) as having special flood hazards unless the:

(1) community in which that area is located participates in the national flood insurance program; and
(2) building (and any related equipment) is covered by adequate flood insurance.

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) or Individual Applicant located in FEMA-designated special flood hazard areas is certifying that adequate flood insurance has been or will be obtained in the following situations:

(1) for NSF grants for the construction of a building or facility, regardless of the dollar amount of the grant; and
(2) for other NSF grants when more than $25,000 has been budgeted in the proposal for repair, alteration or improvement (construction) of a building or facility.

Certification Regarding Responsible Conduct of Research (RCR)
(This certification is not applicable to proposals for conferences, symposia, and workshops.)

By electronically signing the Certification Pages, the Authorized Organizational Representative is certifying that, in accordance with the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.B., the institution has a plan in place to provide appropriate training and oversight in the responsible and ethical conduct of research to undergraduates, graduate students and postdoctoral researchers who will be supported by NSF to conduct research.
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CERTIFICATION PAGE - CONTINUED

Certification Regarding Organizational Support

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Certification Regarding Federal Tax Obligations

When the proposal exceeds $5,000,000, the Authorized Organizational Representative (or equivalent) is required to complete the following certification regarding Federal tax obligations.
By electronically signing the Certification pages, the Authorized Organizational Representative is certifying that, to the best of their knowledge and belief, the proposing organization:
(1) has filed all Federal tax returns required during the three years preceding this certification;
(2) has not been convicted of a criminal offense under the Internal Revenue Code of 1986; and
(3) has not, more than 90 days prior to this certification, been notified of any unpaid Federal tax assessment for which the liability remains unsatisfied, unless the assessment is the subject of an installment agreement or offer in compromise that has been approved by the Internal Revenue Service and is not in default, or the assessment is the subject of a non-frivolous administrative or judicial proceeding.

Certification Regarding Unpaid Federal Tax Liability

When the proposing organization is a corporation, the Authorized Organizational Representative (or equivalent) is required to complete the following certification regarding Federal Tax Liability:

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) is certifying that the corporation has no unpaid Federal tax liability that has been assessed, for which all judicial and administrative remedies have been exhausted or lapsed, and that is not being paid in a timely manner pursuant to an agreement with the authority responsible for collecting the tax liability.

Certification Regarding Criminal Convictions

When the proposing organization is a corporation, the Authorized Organizational Representative (or equivalent) is required to complete the following certification regarding Criminal Convictions:

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) is certifying that the corporation has not been convicted of a felony criminal violation under any Federal law within the 24 months preceding the date on which the certification is signed.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME **Paul C Below**	**Electronic Signature**	**Aug 13 2015 4:09PM**

TELEPHONE NUMBER	EMAIL ADDRESS	FAX NUMBER
319-335-2123	**paul-below@uiowa.edu**	**319-335-2130**

Not for distribution

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 15-1 **PD 98-1620** **08/15/15**	**FOR NSF USE ONLY** **NSF PROPOSAL NUMBER**
FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.) **OCE - MARINE GEOLOGY AND GEOPHYSICS**	**1558855**

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
08/14/2015	2	06040000 OCE	1620	069687242	03/04/2017 1:16pm S

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)	SHOW PREVIOUS AWARD NO. IF THIS IS	IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY?
593102112	☐ A RENEWAL ☐ AN ACCOMPLISHMENT-BASED RENEWAL	YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE **University of South Florida**	ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE **University of South Florida** **3702 Spectrum Blvd.** **Tampa, FL. 336129446**
AWARDEE ORGANIZATION CODE (IF KNOWN) **0015370000**	
NAME OF PRIMARY PLACE OF PERF **University of South Florida**	ADDRESS OF PRIMARY PLACE OF PERF, INCLUDING 9 DIGIT ZIP CODE **University of South Florida** **4202 East Fowler Ave.** **Tampa ,FL ,336205201 ,US.**

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
☐ SMALL BUSINESS ☐ MINORITY BUSINESS
☐ FOR-PROFIT ORGANIZATION ☐ WOMAN-OWNED BUSINESS
☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **Collaborative Research: Subduction Initiation and development of the nascent Izu-Bonin-Mariana arc: Investigation of IODP Expedition 352 whole rocks and glasses**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ **104,196**	**24** months	**06/15/16**	

THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW
- ☐ BEGINNING INVESTIGATOR (GPG I.G.2)
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- ☒ INTERNATIONAL ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j) **IT**
- ☒ COLLABORATIVE STATUS **A collaborative proposal from multiple organizations (GPG II.D.4.b)**

PI/PD DEPARTMENT **Department of Geology**	PI/PD POSTAL ADDRESS **4202 East Fowler Avenue** **SCA 528** **Tampa, FL 33620** **United States**
PI/PD FAX NUMBER **813-974-2654**	

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Email Address
PI/PD NAME **Jeffrey G Ryan**	PhD	1989	813-974-1598	ryan@mail.usf.edu
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

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(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ''Disclosure of Lobbying Activities,'' in accordance with its instructions.
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CERTIFICATION PAGE - CONTINUED

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(2) has not been convicted of a criminal offense under the Internal Revenue Code of 1986; and
(3) has not, more than 90 days prior to this certification, been notified of any unpaid Federal tax assessment for which the liability remains unsatisfied, unless the assessment is the subject of an installment agreement or offer in compromise that has been approved by the Internal Revenue Service and is not in default, or the assessment is the subject of a non-frivolous administrative or judicial proceeding.

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AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME Kelley Schuler	Electronic Signature	Aug 14 2015 2:46PM

TELEPHONE NUMBER	EMAIL ADDRESS	FAX NUMBER
	kschuler@usf.edu	

Not for distribution

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 15-1	FOR NSF USE ONLY
PD 98-1620 08/15/15	NSF PROPOSAL NUMBER
FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.) OCE - MARINE GEOLOGY AND GEOPHYSICS	1558689

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
08/13/2015	2	06040000 OCE	1620	072983455	03/04/2017 1:17pm S

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)	SHOW PREVIOUS AWARD NO. IF THIS IS	IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY?
876000528	☐ A RENEWAL ☐ AN ACCOMPLISHMENT-BASED RENEWAL	YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE	ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE
Utah State University	Utah State University Sponsored Programs Office Logan, UT. 843221415
AWARDEE ORGANIZATION CODE (IF KNOWN) 0036772000	
NAME OF PRIMARY PLACE OF PERF Utah State University	ADDRESS OF PRIMARY PLACE OF PERF, INCLUDING 9 DIGIT ZIP CODE Utah State University 4505 Old Main Hill Logan ,UT ,843224505 ,US.

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
☐ SMALL BUSINESS ☐ MINORITY BUSINESS
☐ FOR-PROFIT ORGANIZATION ☐ WOMAN-OWNED BUSINESS
☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT: **Collaborative Research: Subduction Initiation and development of the nascent Izu-Bonin-Mariana arc: A Petrologic and Geochemical Investigation of IODP Expedition 352 whole rocks an**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ 96,271	24 months	06/01/16	

THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

- ☐ BEGINNING INVESTIGATOR (GPG I.G.2)
- ☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C.1.e)
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- ☐ HISTORIC PLACES (GPG II.C.2.j)
- ☐ VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date ________ PHS Animal Welfare Assurance Number ________
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- ☐ HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number ________ Exemption Subsection ________ or IRB App. Date ________
- ☐ INTERNATIONAL ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j) ________
- ☒ COLLABORATIVE STATUS **A collaborative proposal from multiple organizations (GPG II.D.4.b)**

PI/PD DEPARTMENT	PI/PD POSTAL ADDRESS
Department of Geology	4505 Old Main Hill Utah State University Logan, UT 84322 United States
PI/PD FAX NUMBER 435-797-1588	

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Email Address
PI/PD NAME John W Shervais	PhD	1979	435-797-1274	john.shervais@usu.edu
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

CERTIFICATION PAGE

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Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

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The undersigned certifies, to the best of his or her knowledge and belief, that:
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(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ''Disclosure of Lobbying Activities,'' in accordance with its instructions.
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CERTIFICATION PAGE - CONTINUED

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AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME **Katie Dana**	**Electronic Signature**	**Aug 13 2015 6:34PM**

TELEPHONE NUMBER	EMAIL ADDRESS	FAX NUMBER
435-797-0943	**Katie.Dana@usu.edu**	

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 15-1

PD 98-1620 **08/15/15**

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)

OCE - MARINE GEOLOGY AND GEOPHYSICS

FOR NSF USE ONLY

NSF PROPOSAL NUMBER

1559054

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
08/17/2015	2	06040000 OCE	1620	144017188	03/04/2017 1:17pm S

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)

223011455

SHOW PREVIOUS AWARD NO. IF THIS IS
☐ A RENEWAL
☐ AN ACCOMPLISHMENT-BASED RENEWAL

IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE

University of Rhode Island

AWARDEE ORGANIZATION CODE (IF KNOWN)

0034140000

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE

University of Rhode Island
Research Office
Kingston, RI. 028811967

NAME OF PRIMARY PLACE OF PERF

University of Rhode Island

ADDRESS OF PRIMARY PLACE OF PERF, INCLUDING 9 DIGIT ZIP CODE

University of Rhode Island
Narragansett Bay Campus
Narragansett ,RI ,028821197 ,US.

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
☐ SMALL BUSINESS ☐ MINORITY BUSINESS
☐ FOR-PROFIT ORGANIZATION ☐ WOMAN-OWNED BUSINESS
☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **Collaborative Research: Initiation and development of the nascent Izu-Bonin-Mariana arc: A Petrologic and Geochemical Investigation of IODP Expedition 352 whole rocks an**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ 56,993	24 months	06/01/16	

THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW
☐ BEGINNING INVESTIGATOR (GPG I.G.2)
☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C.1.e)
☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
☐ HISTORIC PLACES (GPG II.C.2.j)
☐ VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date ________
PHS Animal Welfare Assurance Number ________
☒ FUNDING MECHANISM **Research - other than RAPID or EAGER**
☐ HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number ________
Exemption Subsection ________ or IRB App. Date ________
☐ INTERNATIONAL ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j)
☒ COLLABORATIVE STATUS
A collaborative proposal from multiple organizations (GPG II.D.4.b)

PI/PD DEPARTMENT
Graduate School of Oceanography

PI/PD FAX NUMBER
401-874-6811

PI/PD POSTAL ADDRESS
Narragansett Bay Campus

Narragansett, RI 02882
United States

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Email Address
PI/PD NAME Katherine A Kelley	DPhil	2004	401-874-6838	kelley@gso.uri.edu
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

CERTIFICATION PAGE

Certification for Authorized Organizational Representative (or Equivalent) or Individual Applicant

By electronically signing and submitting this proposal, the Authorized Organizational Representative (AOR) or Individual Applicant is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding conflict of interest (when applicable), drug-free workplace, debarment and suspension, lobbying activities (see below), nondiscrimination, flood hazard insurance (when applicable), responsible conduct of research, organizational support, Federal tax obligations, unpaid Federal tax liability, and criminal convictions as set forth in the NSF Proposal & Award Policies & Procedures Guide,Part I: the Grant Proposal Guide (GPG). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U.S. Code, Title 18, Section 1001).

Certification Regarding Conflict of Interest

The AOR is required to complete certifications stating that the organization has implemented and is enforcing a written policy on conflicts of interest (COI), consistent with the provisions of AAG Chapter IV.A.; that, to the best of his/her knowledge, all financial disclosures required by the conflict of interest policy were made; and that conflicts of interest, if any, were, or prior to the organization's expenditure of any funds under the award, will be, satisfactorily managed, reduced or eliminated in accordance with the organization's conflict of interest policy. Conflicts that cannot be satisfactorily managed, reduced or eliminated and research that proceeds without the imposition of conditions or restrictions when a conflict of interest exists, must be disclosed to NSF via use of the Notifications and Requests Module in FastLane.

Drug Free Work Place Certification

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent), is providing the Drug Free Work Place Certification contained in Exhibit II-3 of the Grant Proposal Guide.

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CERTIFICATION PAGE - CONTINUED

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AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME **Franca Cirelli**	**Electronic Signature**	**Aug 17 2015 10:48AM**

TELEPHONE NUMBER	EMAIL ADDRESS	FAX NUMBER
401-874-5891	**franca@uri.edu**	**401-874-4272**

Not for distribution

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 15-1		FOR NSF USE ONLY
PD 98-1620	08/15/15	NSF PROPOSAL NUMBER
FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)		**1558608**
OCE - MARINE GEOLOGY AND GEOPHYSICS		

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
08/13/2015	2	06040000 OCE	1620	143372741	03/04/2017 1:17pm S

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)	SHOW PREVIOUS AWARD NO. IF THIS IS	IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)
526002033	☐ A RENEWAL ☐ AN ACCOMPLISHMENT-BASED RENEWAL	

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE	ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE
Towson University	Towson University 8000 York Road Towson, MD. 212520001
AWARDEE ORGANIZATION CODE (IF KNOWN): 0020990000	
NAME OF PRIMARY PLACE OF PERF	ADDRESS OF PRIMARY PLACE OF PERF, INCLUDING 9 DIGIT ZIP CODE
Towson University	Towson University 8000 York Rd Towson ,MD ,212520001 ,US.

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions) ☐ SMALL BUSINESS ☐ FOR-PROFIT ORGANIZATION ☐ MINORITY BUSINESS ☐ WOMAN-OWNED BUSINESS ☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **Collaborative Research: Subduction Initiation and development of the nascent Izu-Bonin-Mariana arc: A Petrologic and Geochemical Investigation of IODP Expedition 352 whole rocks an**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ 46,533	24 months	06/01/16	

THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW
- ☒ BEGINNING INVESTIGATOR (GPG I.G.2)
- ☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C.1.e)
- ☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
- ☐ HISTORIC PLACES (GPG II.C.2.j)
- ☐ VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date ________ PHS Animal Welfare Assurance Number ________
- ☒ FUNDING MECHANISM **Research - other than RAPID or EAGER**
- ☐ HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number ________ Exemption Subsection ________ or IRB App. Date ________
- ☐ INTERNATIONAL ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j) ________
- ☒ COLLABORATIVE STATUS **A collaborative proposal from multiple organizations (GPG II.D.4.b)**

PI/PD DEPARTMENT	PI/PD POSTAL ADDRESS
Physics, Astronomy, and Geosciences	8000 York Rd Towson, MD 212520001 United States
PI/PD FAX NUMBER	

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Email Address
PI/PD NAME Wendy R Nelson	PhD	2009	814-574-8280	wrnelson@towson.edu
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

CERTIFICATION PAGE

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CERTIFICATION PAGE - CONTINUED

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AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME Lissa Rapkin	Electronic Signature	Aug 13 2015 2:50PM

TELEPHONE NUMBER	EMAIL ADDRESS	FAX NUMBER
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PROJECT SUMMARY

Overview: IODP Expedition 352 to the Bonin forearc drilled 1.22 km of igneous rocks related to subduction initiation and the early development of the Izu-Bonin-Mariana arc. The expedition drilled four sites, two into basalt, two in boninite. Feeder systems were encountered beneath each lava type, illustrating that the entire extant sequence of lavas was drilled at two sites. In collaboration with other members of the shipboard scientific party, we intend to comprehensively analyze drill core from all four sites. Our overarching goal is to document the evolution of melting processes and variations in the fluid, solid, and magma fluxes through the nascent mantle wedge, both from subduction initiation onward and as the mode of magma generation changed from largely decompression melting to flux melting. We will collect a wealth of data, including: major and trace element compositions of glasses (Reagan, Iowa); Oxygen isotopes, water and CO_2 concentrations in glasses (Reagan, J. Eiler, M. Brounce, and G. Rossman, Cal. Tech.); $^{16}O^{1}H^-$ concentrations in pyroxenes (M. Turner, Macquarie Univ.); $Fe^{3+}/\sum Fe$ ratios in glasses (Kelley, GSO/URI); concentrations of fluid-mobile elements and B-Li isotopes in whole rocks and glasses (Ryan, USF); radiogenic Re-Os isotopes and PGE abundances in whole rocks and glasses (Nelson, TU); and major element and trace element compositions of whole rocks (Shervais, USU). The project addresses principal objectives of the IODP Initial Science Plan including testing the validity of the ophiolite model and understanding the initial origins of continental crust, and the GeoPRISMS science plan question of: What are the physical and chemical conditions that control subduction zone initiation and the early development of arc systems?

Intellectual merit: Data collected by the PIs, collaborators, and students covered by this proposal, as well as by other shipboard scientists funded elsewhere, will be will be used to document changes in magma compositions through time for a nascent arc from the initiation of subduction onward. We will address four principal hypotheses developed based on preliminary data: (1) fore-arc basalts (FAB) are generated by decompression melting in a unique high temperature, low-pressure environment during rapid sea-floor spreading related to subduction initiation; (2) The mantle sources for FAB and boninite are unusually depleted and have an ancient recycled component; (3) Low- and high-Si boninites from Sites U1439 and U1442 were largely generated in succession from depleted mantle left after generation of FAB as spreading rates decreased and the involvement of subducted fluids increased; and (4) Magma generation migrated landward and to lower pressures with time. By addressing these hypotheses we will address the greatest gaps in our understanding of magma genesis associated with subduction initiation and early arc development, including how, when, and why source compositions and associated mass flow and melting processes changed through time. This collected work will create an unmatched understanding of the geology and chemostratigraphy of nascent arc crust.

Broader impacts: The proposed project helps to cement new collaborative relationships among these PIs and institutions that were initiated during IODP Expedition 352, and will aid in fostering the broader international collaborative efforts of the Shipboard Science Team, which involved researchers from eight different countries. One mid-career (Kelley) and two early career (Nelson, Brounce) female scientists will be funded with this proposal. Reagan, Shervais, and Ryan will be using this project to support graduate training at their institutions. As part of the GEODE project, Ryan will integrate geo-data resources from IODP including the Bonin arc expeditions with Google Earth for use in classroom teaching and undergraduate research. Kelley, Ryan, and Nelson will involve undergraduate students in sample processing, hands-on data collection and presentation of research results.

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Appendix Items:

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

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Collaborative Research: Subduction Initiation and development of the nascent Izu-Bonin-Mariana arc: A Petrologic and Geochemical Investigation of IODP Expedition 352 whole rocks and glasses

Mark Reagan, Katherine Kelley, Wendy Nelson, Jeff Ryan, John Shervais

Subduction initiation leading to the formation of modern intra-oceanic island arcs is a critical but poorly understood process, and has implications for the onset of Phanerozoic-style plate tectonics (e.g. Stern, 2005; van Hunen & Moyen, 2012; Gerya, 2014) and the origin of continental crust (e.g. Taylor & McLennan, 1995; Hawkesworth & Kemp, 2006). Keys to understanding how new subduction zones come into being are preserved in the rocks that form in response to this singular event in the life of an island arc. The geochemical compositions and petrologic character of these rocks, their isotopic compositions, and their stratigraphic relationships all provide clues about the evolution of the melting process and the fluid, solid, and magma fluxes through the nascent mantle wedge through time. IODP Expedition 352 was designed to attack these questions directly by drilling in the non-accreting fore-arc adjacent to the leading edge of the Izu-Bonin upper plate, which preserves crust formed during the earliest stages of subduction (Expedition 352 Scientists, 2015). The lithologies exposed in this setting mimic those found in many ophiolites, and may provide a direct analogue for ophiolite formation (Reagan et al., 2010; Ishizuka et al., 2014).

This proposal requests funding to support detailed investigation of the first crust produced when subduction begins by analyzing igneous rocks drilled during IODP Expedition 352. It addresses principal objectives of the IODP Initial Science Plan, including testing the validity of the ophiolite model and understanding the initial origins of continental crust. It also addresses a prime question for the GeoPRISMS theme of *Subduction Cycles and Deformation: What are the physical and chemical conditions that control subduction zone initiation and the early development of arc systems?*

Background: Expedition 352 was undertaken 30 July–29 September 2014 by co-chiefs Julian Pearce and Mark Reagan, staff scientist Katerina Petronotis, and 25 expedition scientists to better understand subduction initiation in the Izu-Bonin-Mariana (IBM) fore-arc, and its consequences for crust generation, mantle convection, and mantle composition. Earlier dredging, drilling, and diving along the inner trench walls of the IBM fore-arc found an ophiolitic suite of rocks including depleted peridotites, gabbros, tholeiitic basalts and boninites (e.g., Bloomer, 1983). The basalts were originally interpreted to be trapped MORB (Johnson & Fryer, 1990) or back-arc basin (DeBari et al., 1999) crust. Subsequent diving discovered that the tholeiitic basalts and related intrusive rocks cropped out over broad areas in the Mariana and Bonin fore-arcs and had synchronous ages of ~51.5 Ma (Ishizuka et al., 2011; Reagan et al., 2013). These lavas were termed “fore-arc basalts” (FAB) to distinguish them from lavas generated in other tectonic settings and to illustrate their presence in an oceanic fore-arc (Reagan et al., 2010). The diving also confirmed that the stratigraphy in the fore-arc indeed mimicked that of continental ophiolites, with a stratigraphy from deep to shallow and east to west of depleted peridotites, gabbro, sheeted intrusions, basalts, and boninite (Fig. 1).

FAB were shown to have depleted light rare earth element (REE) patterns, but with lower overall REE concentrations and lower Ti/V ratios compared to normal MORB or Philippine Plate back-arc lavas. FAB genesis, therefore, involved more depleted sources and/or higher degrees of melting than other sea-floor spreading environments (Reagan et al., 2010). Low Ti/V ratios also have been attributed to subduction-related oxidation of V (Shervais, 1982). This contention is supported by slightly elevated Fe^{3+}/Fe ratios in FAB glasses from the Mariana fore-arc, indicating an oxygen fugacity that was a factor of two higher than MORB (Brounce et al., in press). Concentrations of fluid-mobile elements, such as Rb, K, and U are highly variable in whole rocks, whereas they have narrower depleted MORB-like concentrations in glasses. Pb, Sr, Nd and Hf isotopic compositions of most FAB show that, like other IBM arc and back-arc magmas, they are derived from a mantle similar to the source for Indian Ocean MORB (Pearce et al., 19999; Ishizuka et al., 2011), although some have compositions transitional toward Pacific MORB (Reagan et al., 2010). FAB genesis was attributed to near-trench sea-floor spreading and decompression melting associated with subduction initiation based on a model originally put forward by (Stern & Bloomer, 1992).

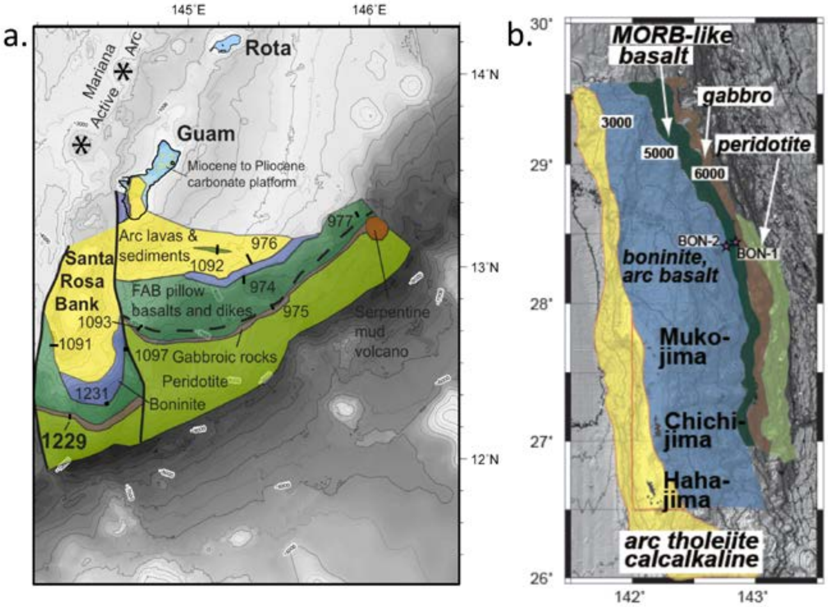

Figure 1. Geological sketch maps of the (a) Mariana fore-arc (Reagan et al., 2013) and (b) Bonin fore-arc (after Ishizuka et al., 2011). Numbers and associated tracks in (a) are for Shinkai 6500 dives conducted during expeditions YK06-12, YK08-08, and YK10-12.

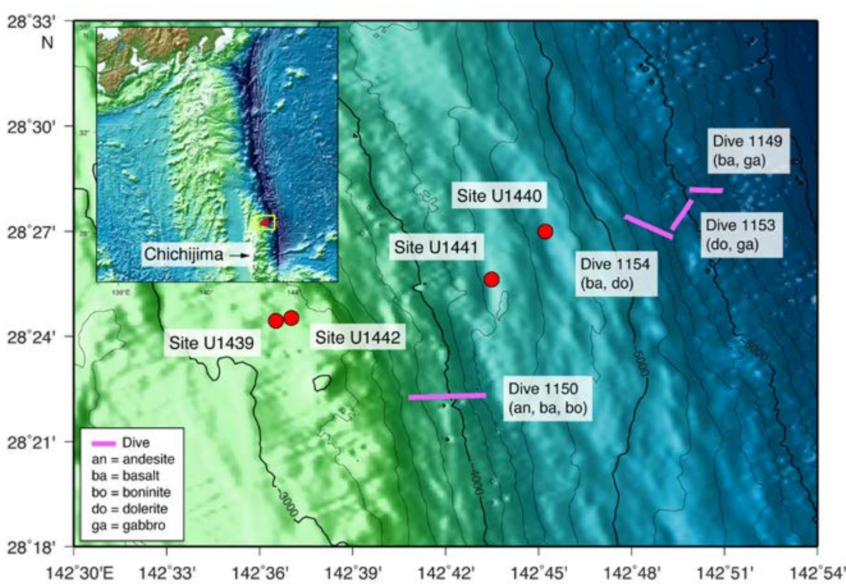

Figure 2. Location of Sites U1439–U1442 for Expedition 352 and nearby dive locations (Ishizuka et al., 2011) illustrating the rock types encountered. Figure from Expedition 352 Scientists (2015).

Boninites were first described and defined in the Bonin Islands (Petersen, 1891; Umino, 1985). They are andesites with very high concentrations of Mg and Cr, low concentrations of CaO and Al_2O_3, U-shaped REE patterns, low REE and high-field-strength element concentrations, high Zr/Sm, and relatively high concentrations of fluid mobile elements, such as K, Rb, and Pb. They have been attributed to melting of shallow, depleted harzburgite by flux melting involving fluids from subducted pelagic sediment and basaltic crust (e.g. Meijer, 1980; Pearce et al., 1992). Boninites from the Bonin Islands have ages ranging from 45-48 Ma (Ishizuka et al., 2006). Isotopic compositions of Pb are dominated by the input of subducted Pacific crust. Nd and Hf isotope compositions suggest that that boninites were derived from mantle with compositions transitional between Pacific and Indian MORB, although these data also are consistent with an influence of subducted fluids (e.g. Pearce et al., 1999; Taylor et al, 1994; Reagan et al., 2010). Peridotites in the IBM fore-arc have unusually low Os isotopic compositions reflecting an ancient depletion (Parkinson et al., 1998). This old, highly depleted mantle rarely melts because of its lack of fertility (Bizimis et al., 2007; Warren and Shirey, 2012). Nevertheless, Os isotopic compositions of Bonin island chromites approach those of this depleted mantle (Suzuki et al., 2011), suggesting that it is involved in boninite genesis.

Lavas from DSDP Sites 458 and 459 have trace element concentrations and ages that are transitional between FAB and MORB, linking these two lava types in time and space (Reagan et al., 2010). Younger lavas transitional between boninites and normal arc rocks erupted between 45 and 42 Ma on the Bonin Ridge (Ishizuka et al., 2006) and on Guam (Hickey-Vargas & Reagan, 1987). The first relatively normal tholeiitic and calcalkaline arc lavas began erupting at ~45 Ma (Ishizuka et al., 2006; Reagan et al., 2008), indicating that by this time, near-normal configurations of mantle flow, subduction-related fluid formation, and melting had been established in the IBM arc.

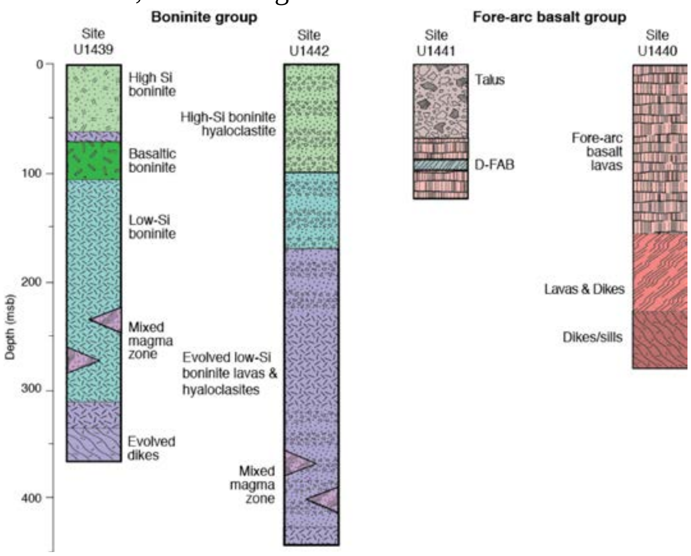

Figure 3. Schematic igneous stratigraphic columns for Expedition 352 drill sites. Sites U1439 and U1442, consis of boninite group lavas and dikes, whereas Sites U1441 and U1440 consist of fore-arc basalts, including lavas an dikes or sills. Site U1442 includes more volcaniclastics than Site U1439, which has lava flows and a basal sequence of sheeted intrusions interpreted to be dikes. Highly evolved low-Si to basaltic boninite-series make up more than half of Site U1442 but only 20 m at the base o the lava sequence at Site U1439. Overlying lavas are variably differentiated. D-FAB is an ultra-depleted variety of FAB with exceptionally low Ti concentrations. Figure from Expedition 352 Scientists (2015).

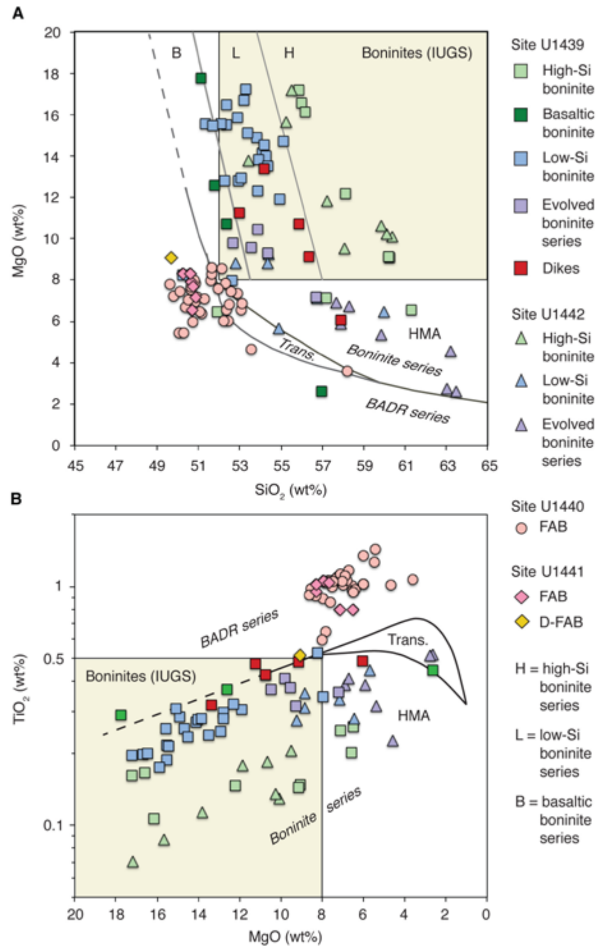

Figure 4. (A) MgO vs. SiO_2 and (B) TiO_2 vs. MgO diagrams were used to classify the volcanic rocks and dikes sampled during Expedition 352. Data were collected onboard by ICP-AES techniques. Boninites are defined by IUGS (Le Bas, 2000), and plot in the shaded rectangular fields on both diagrams. The dividing line between the boninite and the basalt-andesite-dacite-rhyolite (BADR) series is from (Pearce & Robinson, 2010). Differentiated lavas related to these three types of boninites are considered members of the basaltic boninite, low-Si boninite, and high-Si boninite series. trans. = transitional. Figure from Expedition 352 Scientists (2015).

Note that although a general volcanic stratigraphy was established before Expedition 352, it was a composite based on dredging, submersible grab sampling, and coring at widely spaced localities. Expedition 352 provided the stratigraphic context needed to refine how crust developed and source compositions changed after subduction initiation. The expedition also provided an abundance of fresh FAB and boninite glasses for detailed analysis of geochemically pristine samples.

IODP Expedition 352: The principal goal of Expedition 352 was to drill through the boninite to FAB volcanic sequence of the Bonin fore-arc to obtain a high-fidelity record of magmatic evolution. The expedition took place from 30 July to 29 September 2014. The drilling plan called for two sites. Site

U1440 was located at about 4800 m water depth, and aimed to sample from FAB lavas to sheeted dikes (Fig. 2). Site U1439 was drilled ~15 km farther from the trench at ~3100 m water depth, and aimed to core from boninite downward to FAB lavas. Hole stability issues led to premature termination of drilling at both sites (U1440 = 387.4 mbsf and U1439 = 561.7 mbsf). Drilling in the casing at these primary sites freed enough time to allow coring at two additional sites, U1441 and U1442. In total, 1.22 km of igneous basement and 0.46 km of overlying sediment, provide diverse, stratigraphically controlled suites of volcanic rocks related to the onset of subduction and earliest arc development. When considered together with core from DSDP site 458, the expedition provided representative samples for the complete volcanic stratigraphy of an in-situ and intact fore-arc generated during subduction initiation.

Shipboard geochemical data were obtained by ICP-AES and by portable XRF spectrometry. Up to six samples were selected daily during drilling to provide a representative suite for ICP-AES analysis and a companion thin section for petrographic analysis. A Thermo-Fisher Niton portable XRF (pXRF) spectrometer was used to provide high spatial resolution, quantitative analyses of Ca, Ti, K, Sr, Zr, Cu, Zn, and Cr on cut surfaces in order to establish a high-resolution chemical stratigraphy of the core while petrologic logging was in progress (Expedition 352 Scientists, 2015).

Boninite Sites U1439 and U1442. The igneous basement at both sites consists of pillow lavas, massive sheet flows, hyaloclastites, subaqueous pyroclastic flow deposits, and other igneous breccias (Fig. 3). The lowermost unit of Site U1439 consists of ~50 m of dolerites that are interpreted to represent a feeder dike complex. Virtually all samples from Sites U1439 and U1442 plot in the boninite field defined by the IUGS (see Fig. 4) or its extrapolation to more evolved compositions (Pearce and Robinson, 2010). The

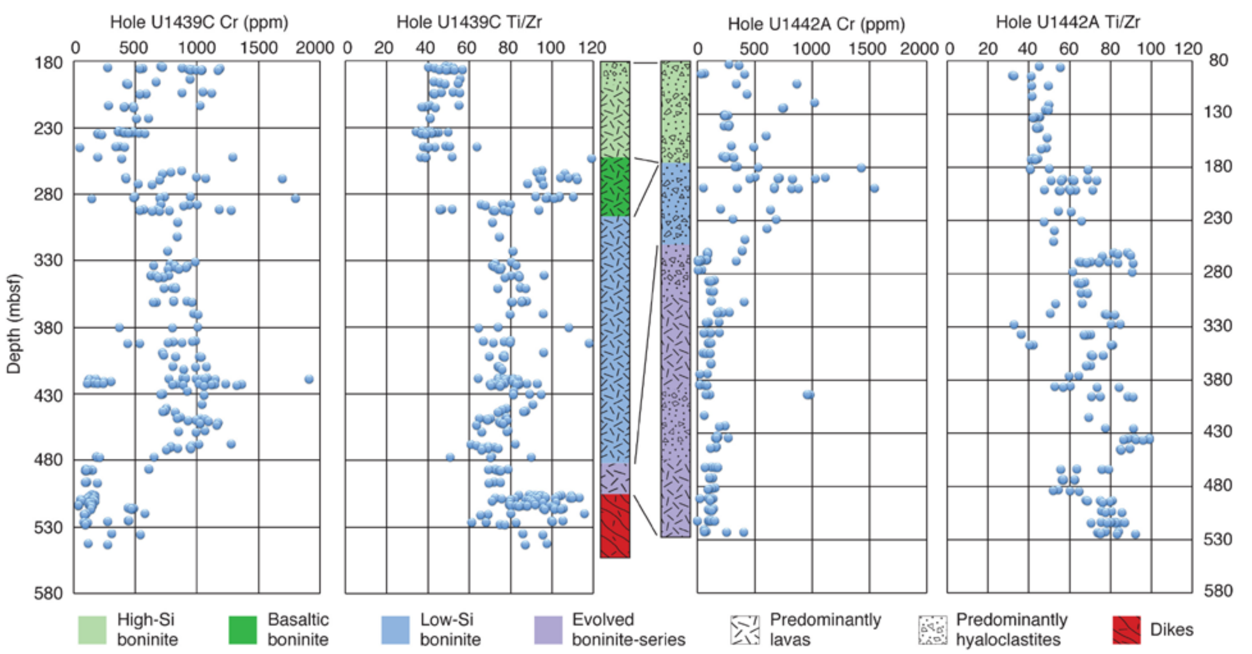

Figure 5. Plots of Cr concentrations and Ti/Zr ratios with depth for Holes U1439C and U1442A. The central colored bars represent the stratigraphic columns for these two holes, and illustrate our first correlation between units. High-Si, low-Si, and basaltic boninites were generally found to have Ti/Zr = 40-60, 60-95, and 90-120 respectively. With the exception of the high-Si boninites atop both holes, most units have minor interlayered strata with other boninitic compositions. Figure from Expedition 352 Scientists (2015).

shipboard scientists subdivided boninites into low-Si and high-Si varieties based on shipboard results. The high-Si boninites are akin to the low-Ca boninites (Crawford et al., 1989) from Chichijima, whereas low-Si boninite series lavas are more like the transitional boninitic lavas from DSDP Site 458 (cf. Reagan et al., 2010). Some samples were given a shipboard classification of “basaltic boninites” because they had boninitic trace element compositions but basaltic SiO_2 concentrations. Differentiated high-Mg andesites that follow liquid lines of descent from parental boninites were considered to be boninite-series lavas. Boninites are petrographically distinct from FAB, in that they are typically highly vesicular and porphyritic (opx-ol in high-Si boninites, ol-px±chrom±plag in low-Si and basaltic boninites).

Sites U1439 and U1442 have chemostratigraphic similarities, but also have surprising differences considering that they are only ~1.3 km apart (Fig. 3). Lavas from both sites have more primitive compositions upward based on Cr concentrations. Highly evolved low-Si to basaltic boninite-series lavas with low Cr concentrations make up more than half of Site U1442 but only 20 m at the base of the lava sequence at Site U1439 (Fig. 5). Overlying the basal differentiated lavas at both sites are units dominated by low-Si boninite lavas with highly variable Cr concentrations, indicating that some magmas underwent significant crystal fractionation, whereas others rose to the surface essentially unfractionated. Mingling between magmas with high and low Cr concentrations is common in this unit. High-Si boninites cap both sites. Most of these lavas are relatively primitive, with Cr concentrations of 200–1600 ppm (Fig. 5) and MgO of 9–17 wt%. The extreme depletion of the mantle sources and degrees of melting for all boninite lavas is reflected in their low TiO_2 concentrations (Fig. 4). This is particularly true of high-Si boninites, which have TiO_2 <0.26 wt%. Ti/Zr ratios are lowest in these high-Si boninites (Fig. 5), possibly related to mobilization of Zr in a slab-melt subduction component (Taylor et al. 1994).

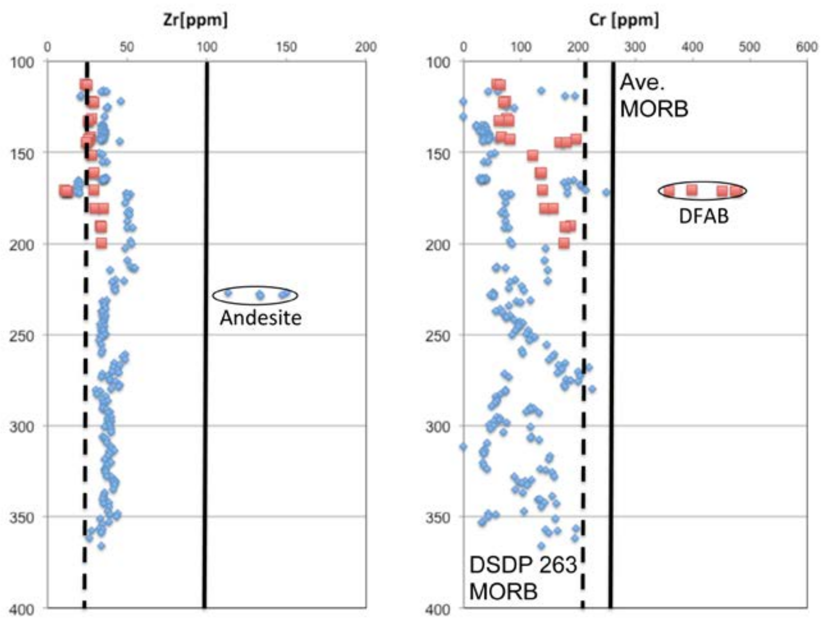

Figure 6. Plot of Zr and Cr concentrations in ppm against depth in hole for Sites U1440 (blue diamonds) and U1441 (red squares). The andesite discussed in the text and DFAB are illustrated. Also shown is an average NMORB Gale et al., 2013) and a strongly depleted MORB, which is a Paleocene lava from DSDP Site 263 in the north Indian Ocean seafloor (Jenner & O'Neill, 2012).

FAB Sites U1440 and U1441. Igneous rocks at these two sites, which are closer to the trench and lie at significantly deeper depths, are chemically and petrographically distinct from the boninites at the previous two sites. The igneous stratigraphy at Hole U1440B comprises over 175 m of basaltic pillow lavas, sheet flows, and hyaloclastites followed by ~60 m of lavas interspersed with dolerite dikes or sills, and ending in ~40 m of shallow intrusive rocks that represent multiple intrusions (Fig. 3). This sequence is reminiscent of those in oceanic crust and ophiolites (e.g. Whattam & Stern, 2011; Dilek & Flower, 2003), and an indicator that the entire extant lava sequence at this location was drilled. The igneous rocks in Hole U1441A are entirely lavas, with the upper half consisting of talus.

Major element compositions of the igneous rocks cored at Sites U1440 and U1441 are similar to one another and to FAB from dives in the IBM fore-arc. Almost all of the lavas and dikes classify as tholeiitic basalts by standard IUGS criteria (Fig. 4). Exceptions at Site U1440 are rare basaltic andesites, and one glass-rich andesite. FAB from the drill core have MORB-like MgO concentrations (5–9 wt%). The basalts from Sites U1440 and U1441 are aphyric to sparsely porphyritic with glassy to microcrystalline plagioclase-augite–magnetite groundmasses and low vesicularity (0 to 5%). Dolerites were identified by their subophitic textures coupled with the same mineralogy as the lavas.

Portable XRF data show that FAB have significantly lower Zr concentrations than average MORB, but are similar to those of the most depleted MORB (Fig. 6). Concentrations of Cr are low compared to normal and depleted MORB (Fig. 6). Depleted FAB (DFAB) with unusually low concentrations of incompatible trace elements (e.g. Zr) from Hole U1441A have the highest Cr concentrations and are the least fractionated of any lava at both sites.

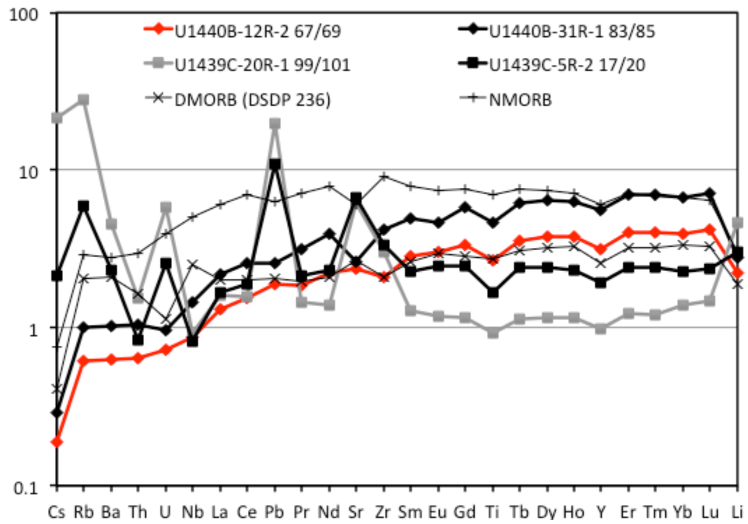

Figure 7. Primitive mantle (Sun & McDonough, 1989) normalized concentrations of incompatible trace elements in selected glasses from IODP Expedition 352. FAB compositions are illustrated with triangles, boninites with squares. Shown for comparison are trace element patterns for NMORB (Gale et al., 2013), and a highly depleted MORB from DSDP Site 236 (Jenner & O'Neill, 2012). Elements (except Li) are ordered as in (Workman & Hart, 2005).

Preliminary post-expedition data: Initial post-expedition work on a limited suite of samples has been funded by small (<$15k) post-expedition activity (PEA) awards from Ocean Leadership to some PIs of this proposal. These funds are being used to supplement shipboard whole rock analyses with wavelength dispersive XRF analysis and solution ICPMS, to carry out radiogenic and stable isotope analyses on selected samples, and for the first analyses of glasses.

A representative selection of 32 pristine FAB and boninite glasses has been analyzed by electron microprobe. Representative analyses are shown in Table 1. These analyses show that the major element compositions of FAB are similar to those of depleted MORB. Major element oxide totals are mostly greater than 99.4 wt%, suggesting limited water concentrations in the glass. The concentrations of Al, Ti, and Na are low, and concentrations of Fe and Ca are high in these lavas compared to global MORB glasses, which are characteristic of depleted basalts erupted at shallow mid-ocean ridge segments associated with hot mantle (Gale et al., 2014). However, SiO_2 concentrations are unusually high compared to depleted MORB, indicating unusually shallow

Table 1. Major and volatile element analyses of pristine glasses by electon microprobe. Each analysis is an average of 6-10, 10 micron spots.

Sample	U1440B-12R-2	U1440B-19R-1	U1440B-31R-1	U1439C-5R-2	U1439C-20R-1
rock type	FAB	andesite	FAB	high-Si Bon.	low-Si Bon.
SiO_2	51.81	58.58	51.59	60.57	56.56
TiO_2	0.57	1.01	1.00	0.20	0.36
Al_2O_3	14.86	12.23	14.13	14.49	14.11
FeO	9.05	12.31	11.12	6.57	6.71
MnO	0.17	0.20	0.18	0.11	0.12
MgO	8.74	3.58	7.44	4.69	7.75
CaO	13.17	8.14	11.95	8.41	10.10
Na_2O	1.59	2.61	1.91	2.39	2.13
K_2O	0.02	0.19	0.05	0.58	0.27
P_2O_5	0.04	0.10	0.07	0.03	0.04
Total	100.26	98.96	99.44	98.04	98.21
Cl ppm	181	2965	668	585	455
S ppm	862	776	1103	51	61
K/Cl	1.02	0.54	0.57	8.19	4.97

pressures of melting for a ridge segment with hot mantle. The low Cr and moderate Mg concentrations in FAB glasses (average for EMP analyses = 7.4 wt% MgO) suggest that a melt lens was present during the eruption of FAB, which is an attribute of intermediate to fast spreading centers (e.g. Langmuir et al., 1986). The upper lavas in Hole U1440B are more diverse than underlying lavas, and include the most depleted FAB and the andesite. The FAB have lower K/Cl than arc, back-arc, or MORB because of exceedingly low K but moderately high Cl.

Incompatible trace element concentrations determined on glasses by laser-ablation ICPMS in FAB are generally lower than their mid-ocean ridge equivalents, and light REE are more depleted than even depleted MORB (Fig. 7). Enrichments in elements commonly derived from the subducting slab in arcs are not evident in any sample, including the andesite, whose composition is generally consistent with genesis by differentiation of FAB.

Boninite glasses have fractionated compositions compared to whole rocks because of the presence of abundant quench crystals. TiO_2 concentrations for all boninites inversely correlate with K_2O concentrations, which is consistent with control of trace element abundances largely by variable degrees of fluid-flux melting. All boninite glasses have low S, but high Cl concentrations and high K/Cl like arc magmas. We suspect that glasses contain roughly 2-4 % water based on major element oxide totals of 96 to 98%, with high-Si boninite hyaloclastite glasses having the lowest oxide totals.

LA-ICPMS data collected on boninite glasses indicate that high-Si boninites have trace element compositions like those of the type-section boninites from Chichijima with exceedingly low concentrations of REE and most HFS elements, but enrichments in light REE and Zr over middle REE (Fig. 7). Concentrations of elements that typically are mobilized from the subducted slab in volcanic arcs are strongly enriched in these lavas. This is particularly true of the highly fluid mobile elements Cs and Rb. Low-Si boninites have concentrations of REE and HFS elements between those of FAB and the high-Si boninites. The difference in incompatible trace element ratios such as Rb/Ba between the low- and high-Si boninites illustrates that the low-Si boninites are not mixtures between FAB and boninite, but that the source composition evolved through time.

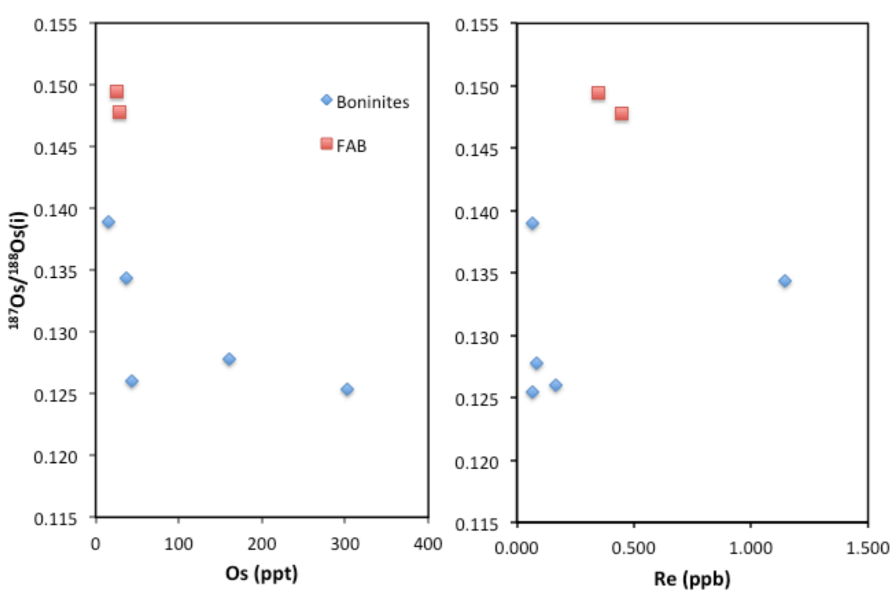

Figure 8. First isotopic compositions of Os plotted against Os and Re concentrations.

Rhenium-osmium isotopic data have been collected on a small subset of boninite-series and FAB pool sample powders (Fig. 8). Age-corrected (48 Ma; Ishizuka et al., 2011) $^{187}Os/^{188}Os$ isotopic data for five boninite-series samples (U1439C and U1442A) have moderately unradiogenic values (0.1254) to radiogenic values (0.1390), consistent with Os isotopic data from the Bonin Islands (Suzuki et al., 2011). The depleted mantle to mildly suprachondritic ratios do not appear to sample the highly depleted ancient mantle found in peridotites from Mariana serpentine mud volcanoes (e.g. Parkinson et al., 1998), but additional measurements on whole powders as well as olivine and spinel separates need to be investigated to assess the full range of mantle contributions. In contrast, the two FAB samples (U1440B) analyzed consistently have mildly radiogenic age-corrected (51.5 Ma; Ishizuka et al., 2011) Os isotopic ratios (0.1484 and 0.1500) with low Os abundances (26-29 ppt). These analyses represent the first Re-Os isotopic data measured on FAB. The radiogenic signatures and mildly elevated Re contents (350-450 ppt) are not consistent with origins from an unaltered, anciently depleted mantle source, but suggest a source with a $^{187}Os/^{188}Os$ isotopic composition higher than that of primitive mantle (cf. Meisel et al., 2001). Note, however, that seawater alteration can add Re to seafloor samples (Standish et al., 2002), resulting in elevated $^{187}Os/^{188}Os$ values over time. At present, the modest $^{187}Re/^{188}Os$ values in FAB compared with those of the boninites do not support this origin, but clearly additional analyses of FAB including hand-picked glasses are needed to further investigate the origin of these relatively radiogenic $^{187}Os/^{188}Os$ ratios. Note also that final $^{187}Os/^{188}Os$ values will depend on precise $^{40}Ar/^{39}Ar$ age determinations that will be forthcoming from expedition scientist Daniel Heaton at Oregon State.

Hypotheses: Based on the limited data available at this stage of post-expedition research, our hypotheses concerning the origin of the IBM fore-arc crust and its relationship to subduction initiation are the following.

1. **FAB are generated by decompression melting in a unique high temperature, low-pressure environment during rapid sea-floor spreading related to subduction initiation.** The high Si contents, combined with low Al, Ti, and Na and high concentrations of Fe and Ca observed in the few analyzed glasses thus far are rare at spreading centers (cf. Gale et al., 2014) and illustrate that the conditions required to generate FAB could have been different from those associated with typical mid-ocean ridge or back-arc spreading. Low and generally increasing Cr concentrations with depth at Hole 1440B are consistent with a persistent melt lens and thus relatively rapid sea-floor spreading. No irrefutable compositional evidence for fluid-flux melting has been found to date. The most significant evidence against this hypothesis is the slightly elevated fO_2 in FAB glasses from DSDP Site 459 (Brounce et al., in press). Most of the tasks listed below are directly aimed at determining whether any of the drilled FAB were affected by subduction, and if so, how the contributions from the subducting slab changed through time.

2. **The mantle sources for FAB and boninite are unusually depleted and have an ancient recycled component.** The low concentrations of incompatible trace elements in FAB suggest either high extents of melting or melting of an already depleted source. Hypothesis 1, the Os isotope compositions shown above, and MORB-like Nd-Hf isotopic compositions of FAB collected elsewhere are more consistent with the former. The latter is supported by the presence of chromite in Bonin island beach sands with low Os isotope compositions (Suzuki et al., 2011). Task 2.3 is specifically geared to test this hypothesis.

3. **Low- and high-Si boninites from Sites U1439 and U1442 were largely generated in succession from depleted mantle left after generation of FAB as spreading rates decreased and the involvement of subducted fluids increased.** The progression from eruption of highly differentiated FAB and basaltic boninite to variably differentiated boninites suggest that early magmatism after subduction initiation accompanied rapid sea-floor spreading and the development of a melt lens, whereas later eruptions of boninites were from ephemeral magma chambers associated with less robust spreading. The increased involvement of subducted constituents whose compositions evolve through time is suggested by the preliminary glass data. All tasks listed below will test various aspects of this hypothesis.

4. **Magma generation migrated landward and to lower pressures with time.** Experimental evidence (e.g. Parman & Grove, 2004) and modeling (e.g. Lee et al., 2009) suggest that boninites are generated under water-rich and low-pressure conditions in the mantle. The migration of magmatism associated with subduction initiation away from the trench is implied by the shipboard observation that both

Holes U1439C and U1440B drilled into dolerites interpreted to be feeder dikes. Modeling of the data collected during this project, in conjunction with experimental work being carried out by Renat Almeev, will directly address how pressures of melting evolved with time.

Proposed work: The greatest gaps in our understanding of magma genesis associated with subduction initiation and early arc development in the IBM system concern how, when, and why source compositions and associated mass flow and melting processes changed through time. We don't understand mantle convection through time after subduction initiation, and we don't know how and when subduction influenced FAB generation. We believe that boninites collected at the drill sites and elsewhere were generated by flux melting of the mantle due to the involvement of a subducted fluid, but we don't know how the composition of this fluid evolved nor how the intensive parameters of melting evolved. Expedition 352 provided the samples needed to address these issues.

Expedition 352 scientists subdivided analytical tasks onboard to comprehensively analyze whole-rock powders and glasses. The major analytical tasks taken on by the PIs of this proposal are listed below. We spell out how the PEA awards are being used and why the additional funds requested here are needed.

Task 1: Glass and mineral phase analyses

Task 1.1: EMP and LAICPMS analyses of glasses (Reagan, Iowa). We have started analyzing fresh glasses by electron microprobe (EMP) for major elements, S and Cl, and by laser ablation inductively coupled mass spectrometry (LA-ICPMS) for trace elements at the University of Iowa (see above). Our preliminary EMP and LA-ICPMS data suggest that the major and trace element compositions of the magmas changed through time as the primary mode of magma generation changed from decompression melting to flux melting. With the complete data set, combined with geochronological data from shipboard scientist Daniel Heaton, we will show when subducted fluids became involved in magma genesis, how the fluid compositions changed through time, how the mantle source composition changed through time, and what this says about how the thermal structure of the subducting slab evolved, thus testing each hypothesis listed above. Major element data collected by EMP will be used to model conditions of magma genesis, for example using the ABS model (Kimura et al., 2009), and the silica geothermometer/barometer of Lee et al. (2009). LA-ICPMS data will show how source compositions, melting extents, and the involvement of fluid liberated from the subducting slab changed as magmas evolved from FAB through high-Si boninite.

PEA funding is covering initial sample preparation and analytical costs for approximately 32 EMP and LA-ICPMS analyses of fresh glass at U. Iowa. The glasses currently being analyzed are the largest glass fragments from the sample suite collected on-board by Reagan. These glasses were readily picked by hand and mounted in epoxy for microbeam analysis with relatively minor labor. A similar number of samples have fresh glass, but will require careful grinding and density/magnetic separation to free the glass from altered portions of the sample. Olivine and pyroxenes also will be separated from boninites as part of the process, offering the opportunity to analyze these minerals for $^{16}O^{1}H^{-}$ concentrations (see below). Much of the funding requested here is to pay a graduate student to conduct these phase separations, and to analyze these samples as part of their thesis research. This student will focus on finishing and interpreting the EMP and LA-ICPMS analyses at Iowa.

Task 1.2: Oxygen isotopes, water and CO_2 in glasses (Reagan, J. Eiler, M. Brounce, and G. Rossman, Cal. Tech.). We intend to analyze glasses for oxygen isotopes by laser fluorination. Pillow rind and hyaloclastite glasses also will be analyzed by FTIR for OH, H_2O, and CO_2 concentrations in George Rossman's lab at Caltech. We will use the well-established OH/H_2O systematics in basalt glasses (Dixon et al., 1995) to potentially identify deviations related to secondary H_2O. This study of volatiles is part of a broader collaboration with expedition scientist Kenji Shimizu, who will be analyzing similar glasses as well as olivine- and pyroxene-hosted glass inclusions for volatile contents using SIMS techniques. Oxygen isotopes will clarify the sources of subducted materials in fore-arc lavas because of the potential to discriminate between the isotopic composition of mantle from the compositions of subducted sediments, altered MORB, and serpentinite (see Eiler et al., 2005). PEA funding will cover approximately 10 O isotope and FTIR analyses of glasses and travel to Caltech. This preliminary work is scheduled for November 21-24, 2015. Once our major and trace element analyses of glasses are completed, we will supplement the O isotope and FTIR analyses with approximately 8-10 additional analyses by conducted by Maryjo Brounce (see letter of support).

Task 1.3: $^{16}O^{1}H^{-}$ concentrations in pyroxenes (M. Turner, Macquarie Univ.). We will analyze pyroxenes from eight boninites and FAB using the SHRIMP SI in Canberra, Australia to determine $^{16}O^{1}H^{-}$ concentrations in these nominally anhydrous minerals (Turner et al., 2015), which are a direct function of the water concentrations of host magmas (Wade et al., 2008). These analyses will provide information about the water contents of parental magmas in the boninites, whose matrix glass water concentrations have been universally lowered by degassing. This is the only way to investigate whether the augite-phenocryst-bearing DFAB was melted to extraordinary levels because of a flux of fluid from the subducting slab. Because of the expense involved, these analyses will be done after major and trace element analyses to make sure we use the most representative samples. We expect that 5-6 of these analyses will be on boninites, and 2-3 will be on FAB. Each sample will have 10-20 pyroxenes analyzed. These analyses will complement K. Shimizu's planned analyses of volatile contents in melt inclusions from olivine and chromite in boninites, providing information about water concentrations. They also will be interpreted in conjunction with oxidation states determined by K. Kelley (see below) and temperatures and pressures of crystallization determined by crystallization experiments using Exp. 352 samples by expedition scientist R. Almeev, and by using olivine-melt, opx-melt, cpx-melt, and cpx-opx thermometers and barometers (e.g. Putrika, 2008) in association with expedition scientists T. Chapman and S. Wattham.

Task 1.4: Fe speciation in glass by XANES (Kelley, GSO/URI). All glasses analyzed by EMP and LA-ICPMS (n=~64) will also be analyzed for $Fe^{3+}/\sum Fe$ ratios by X-ray Absorption Near Edge Structure (XANES) spectroscopy at Beamline 13-ID-E of the Advanced Photon Source, Argonne National Laboratory. The XANES technique has been developed to yield very precise (±0.005) determinations of the $Fe^{3+}/\sum Fe$ ratios in natural silicate glasses of a range of compositions (Cottrell et al., 2009; Pauphas et al., 2014). Kelley and her research group have successfully employed XANES to constrain $Fe^{3+}/\sum Fe$ ratios and, following methods of (Kress & Carmichael, 1991), magmatic/mantle oxygen fugacity in natural magmas from mid-ocean ridges and subduction zones (e.g., Brounce et al., 2014; Kelley & Cottrell, 2012; Kelley & Cottrell, 2012). FAB display a slightly elevated $Fe^{3+}/\sum Fe$ ratio, and consequently, a slightly higher oxygen fugacity, despite few other signatures of the influence of slab-derived components in its formation (Brounce et al., in press), potentially making it a uniquely sensitive tracer of the arrival of slab-derived materials in the mantle source of arc magmas. When coupled with other geochemical measurements and age determinations, these new data will determine whether the prior XANES measurements are typical of FAB, when in the arc initiation sequence oxidizing conditions appear and become dominant, and whether oxidation is directly accompanied by other signatures of the slab or instead leads them in time. This work will directly address hypotheses 1, 3, and 4 outlined above. No PEA funding has been used to determine $Fe^{3+}/\sum Fe$ ratios in Expedition 352 glasses.

Task 1.5: Fluid-mobile elements and B-Li isotopes (Ryan, USF). A subset of our analyzed glasses will be examined for "fluid-mobile" trace elements (B, As, Sb and Li) via laser-ablation ICP-MS using the Perkin-Elmer Elan II DRC quadrupole ICP-MS with an LSX-213 laser ablation system at the University of South Florida. Boron is a highly sensitive indicator of shallow-derived, hydrous slab fluids (Ryan et al., 1996; Savov et al., 2005; Savov et al., 2007), and it is also a conservative species in the oceans with a globally uniform abundance (4.5 ppm B: Uppstrom, 1974). As and Sb are strongly chalcophilic in basaltic systems, but behave like B and Cs during subduction-related fluid-rock exchanges (Noll et al., 1996; Hattori & Guillot, 2007). Li is mobilized in early stage fluid releases from downgoing plates and is enriched in subduction-related lavas, but is unusual in that it partitions strongly into mantle minerals, and as such "maps" mantle compositions (Ryan & Langmuir, 1993; Straub & Layne, 2002; Savov et al., 2005; Savov et al., 2007). These elements are all enriched in IBM serpentinite seamount samples, materials that have been proposed as a possible source for boninite melts (e.g. Parkinson et al., 1998). Removal of these elements from slab materials begins at temperatures <400°C (Bebout et al 1999; Hattori and Guillot 2007), so the hotter extensional environment that we are hypothesizing for Izu-Bonin boninites may limit the degree of B-As-Sb enrichment. Preliminary results on U1439C and U1442A glasses indicate B concentrations in the 1-10 ppm range, and B/Be ratios of 20 or less, as compared to B/Be of up to 200 in young Izu-Bonin arc lavas (Ryan & Langmuir, 1987). As U1440B FABs show no enrichment of Cs or Rb, and little or no Li enrichment, we anticipate low FME abundances, but as boron can be a strong indicator of seawater contributions, it may show systematics consistent with very shallow oceanic magmatism (i.e., inputs from seawater-derived hydrothermal fluids, or seawater altered basaltic crust).

A small number of B and (potentially) Li isotopic measurements will be made on select glasses via SIMS using the Cameca 1280 doubly focusing ion microprobe facility at WHOI, following methods outlined in (Straub & Layne, 2002), and recently updated by Marshall & Monteleone (2015). These data will complement and validate higher-precision results on whole rocks and help answer questions about slab-derived fluids and the nature of the fore-arc mantle source (see below).

Task 2: Whole rock major element, trace element, and isotope geochemistry

Task 2.1: Whole rock major elements by XRF and trace element analyses by ICPMS (Shervais, USU). Shervais will be responsible for whole rock major and trace element analyses by X-ray fluorescence spectrometry and by ICP-MS. A PEA award from Ocean Leadership funded the analysis of shipboard pool samples to confirm the ICP-AES results, provide a more complete trace element suite, and provide an internally consistent data set for all expedition scientists. However, there are only 110 pool samples for all four holes (~27 samples per hole). As a result, the shipboard chemical stratigraphy was based almost entirely on the pXRF partial analyses, carried out largely on sections of whole core or rock fragments. In order to confirm the chemical stratigraphy and geochemical trends in each hole, Shervais' shipboard sampling strategy was designed to augment the pool samples, using the pXRF data as a guide. A total of 144 samples were collected for this purpose, distributed across all four holes, with sample distribution based on cored depth in each hole. The pool samples were provided as pre-ignited powders produced on the JR; the new samples will require significantly more effort to prepare for analysis. Major element analyses will be carried out at USU with a Panalytical 2400 XRF spectrometer equipped with a 3 KW Rh tube. Trace element analyses (14 REE plus 15 other trace elements) will be carried out with a Thermo X Series 2 ICP-MS, also at USU.

These data will address the geochemical evolution of each magma series through time, the relative importance of decompression melting to flux melting and how this varies through time, whether magma compositions reflect fractionation within a crustal magma chamber, or erupt more or less directly from the mantle. These data address directly *Hypotheses 1, 3,* and *4*, discussed above.

Task 2.2: Whole rock fluid-mobile elements (FME) and Li-Be isotopes Ryan (USF). PEA funding to PI Jeff Ryan supported fluid-mobile element abundance measurements on the "pool" whole-rock samples collected collaboratively on the ship plus a selection of adjacent samples selected as checks on sample freshness. In this request we seek to complete fluid-mobile species abundance coverage in Holes U1439C, U1440B, and U1442A, and to examine a subset of these materials for Li and B isotope ratios.

FME abundance and boron isotopic data will allow us to compare our recovered boninites to materials which have been proposed as boninite source rocks (i.e., fore-arc serpentinites: Parkinson et al., 1998), and track the evolution of slab-derived fluid components as subduction processes develops and the locus of magmatism moves away from the trench. Lithium isotopes usually "fingerprint" the convecting upper mantle, which thanks to significant Li concentrations in mantle peridotite and its high diffusion rate has a very uniform signature, even in intraplate and subduction-related settings (e.g., Tomascak et al., 2002; Ryan & Kyle, 2004). However, in circumstances where the mantle is not convectively homogenized, Li isotopic heterogeneity can occur, and correlates with other measures of slab input (e.g. Tomascak et al., 2000). The Expedition 352 boninites offer an interesting test of the model outlined in

Agostini et al (2008), in that an extensively depleted mantle wedge is subject to substantial slab inputs. Li/Yb ratios in the boninites are higher than have been reported in any arc lava (Li/Yb ~13-23) indicating very large Li inputs, though interestingly their Cs/Th ratios fall within the range of FME-enriched arc lavas. It is thus possible that the slab component responsible for Expedition 352 boninites is itself fractionated, with greater abundances of elements, like Li, which appear to mobilize from slabs at higher temperatures.

For whole rocks, secondary alteration due to interactions with seawater is a concern, in particular for B, as its abundance in seawater is high, and it is readily taken up by secondary sheet silicates. To minimize these concerns, careful sample selection on the ship is combined with handpicking of crushed materials and, as required, sample leaching to remove any contamination (following Tanaka & Nakamura, 2005). All samples to be analyzed isotopically will undergo leaching to minimize any potential seawater-related effects.

FME abundances on whole rocks will be conducted via solution ICP-MS methods using the USF Perkin Elmer Elan II DRC system. This work will primarily be completed by undergraduate researchers working under Ryan's supervision as he has done routinely in past projects. Boron sample digestions will follow a modification of the HF-mannitol method (Ishikawa & Nakamura, 1992) to reduce sample TDS and improve B sensitivity. Li isotope measurements will be conducted in the Li labs of Roberta Rudnick and coworkers at the University of Maryland, following their standard two-column procedure and using their Nu Plasma MC-ICPMS system, while B isotopes will be conducted via TIMS at CNR-Pisa in the labs of Sonia Tonarini and Samuele Agostini.

Task 2.3: Radiogenic Re-Os isotopes and PGE abundances (Nelson, TU). In order to understand Re-Os isotopic systematics, we will measure Re-Os isotopes and platinum-group element (PGE – Pt, Ir, Ru, Pd) abundances on both boninite-series and FAB samples. The majority of the data will be collected on whole rock powders. A subset of boninite samples is a prime candidate for measuring the same geochemical data set on olivine and spinel separates. Olivine phenocrysts house micro-sulfides and spinel inclusions; these included minerals are significant hosts for Re-Os and PGE, and are shielded from secondary processes (e.g. Jackson & Shirey, 2011) Spinel is thought to be robust against secondary processes and therefore is more likely to preserve primary geochemical information with often manifests as a less radiogenic $^{187}Os/^{188}Os$ ratio compared to whole rock measurements and thereby provide a more accurate fingerprint of the mantle source (e.g. Standish et al., 2002; Suzuki et al., 2011). PGE abundances provide key insight into the nature of the source material and associated fluids, allowing us to constrain both the degree of source depletion as well as the potential for highly siderophile element mobility that would affect the Re-Os isotopic signature (e.g. Dale et al., 2008). Nelson and an undergraduate student will carry out sample preparation, digestion, and elemental separations at TU. Os isotopes will be measured using TIMS at the Carnegie Institution of Washington, where Nelson is a DTM Visiting Investigator and has access to laboratory and instrumentation facilities. Rhenium and PGE abundances will be measured at TU using a quadrupole ICP-MS.

Task 3. Data integration, presentation of results

Data collected by the PIs, collaborators, and students covered by this proposal, as well as by other shipboard scientists, will be shared as it is generated by shipboard agreement. The data from other scientists will include $^{40}Ar/^{39}Ar$ ages (D. Heaton-A. Koppers [OSU]), Sr-Nd-Hf-Pb isotopes (J. Pearce [Cardiff], Hongyan Li [Guangzhou]), high precision HFSE analyses (M. Kirchenbaur [Koln]), Fe, Mg, and Tl isotopes (J. Prytulac [Imperial College], R. Almeev [Hannover]), volatile compositions of glass inclusions (K. Shimizu [JAMSTEC]), sulfur speciation in volcanic glasses (K. Shimizu), trace element compositions of mineral phases (T. Sakuyama [Osaka]) and basic characterization of mineral phase chemistry (T. Chapman [Sydney]; S. Whattam [Korea]). First results will be presented at the post-cruise meeting on Cyprus May 8-15, 2016, where publication plans will be discussed and revised from those originally outlined during the expedition. Reagan along with fellow expedition co-chief Julian

Pearce will maintain their roles to coordinate and expedite the research of the expedition scientists, including the work in this proposal. All of the PIs will present their research at national and international meetings (e.g. AGU, Goldschmidt). We expect at least 8 peer-reviewed papers to result from the work associated with this proposal. The work of the entire expedition team will create an unmatched understanding of the geology and chemostratigraphy of crust in the Bonin fore-arc, which can be compared and contrasted with ophiolites to better understand their origin (e.g. 45).

Project team and responsibilities

Reagan will coordinate the overall project, and oversee the EMP and LA-ICPMS analyses of glasses. He will conduct the first O isotope and FTIR analyses at Caltech in collaboration with Professors Eiler and Rossman. He will collaborate with Maryjo Brounce for subsequent analyses at Caltech and in overall interpretation of stable isotope and volatile species data. He also will collaborate with Michael Turner at Macquarie University to analyze pyroxenes for $^{16}O^{1}H^{-}$ concentrations (see support letters). He will furnish samples to K. Kelley for Fe speciation analysis. An Iowa graduate student will process samples and conduct future analyses of glasses by EMP and LA-ICPMS.

Shervais and Emily Haugen (USU graduate student) will be responsible for whole rock geochemistry by XRF and ICP-MS, for documenting the volcanic stratigraphy of all four sites, and for correlating the chemical stratigraphy with the physical volcanic stratigraphy. He will also model melting and fractionation trends if present.

Ryan and his students will be responsible for all fluid-mobile element (B, As, Sb, Li) abundance data collection at USF as well as Li and B isotope work with the Woods Hole Oceanographic Institution, Univ. Maryland and CNR-Pisa labs, with which he has had longstanding collaborations.

Nelson and a TU undergraduate student will perform the geochemical digestions and Re-Os-PGE separations at Towson University. Samples will consist of whole rock powders (FAB, boninite-series, and select glasses) as well as olivine and spinel separates from select boninite samples. Nelson will measure Os isotopes by TIMS at the Carnegie Institution of Washington. Re isotopes and PGE abundances will be measured at Towson University using the in-house quadrupole ICP-MS.

Kelley will determine $Fe^{3+}/\sum Fe$ ratios for FAB and boninite glasses, model oxygen fugacity, and interpret these in the context of the major element compositions of the glasses, phase assemblages, age, and stratigraphy.

Brounce will conduct the second round of O isotope and FTIR analyses at Caltech and fully participate in data interpretation.

Turner will analyze pyroxenes for $^{16}O^{1}H^{-}$ concentrations using the SHRIMP SI in Canberra, Australia and fully participate in the interpretation of results.

Broader Impacts of the Proposed Work

The proposed project helps to cement new collaborative relationships among these PIs and institutions that were initiated during IODP Expedition 352, and will aid in fostering the broader international collaborative efforts of the Shipboard Science Team, which involved researchers from eight different countries. One mid-career (Kelley) and two early career (Nelson, Brounce) female scientists will be funded with this proposal. Reagan, Shervais, and Ryan will use this project to support graduate training at their institutions, including training in a broad range of sample preparation and analytical techniques for major element concentrations, trace element concentrations, and stable isotope ratios. Reagan will incorporate results into an upcoming Tectonics & Petrology Seminar (EES:6570) on the ocean floor, and Shervais will incorporate results into his Convergent Margins graduate seminar. Ryan will involve a team of undergraduate researchers in the efforts at USF. Ryan is as well involved as Senior Personnel in the GEODE project, an NSF-Transforming Undergraduate Education in STEM (TUES) funded effort that seeks to integrate geo-data resources from IODP and other data portals with the Google Earth visualization platform for use in classroom teaching and undergraduate research. Visualizing results from the three recent Izu-Bonin Expeditions for student investigation are a focus of Ryan's efforts in this project, and results from the proposed work would become part of this collection as these data are published and placed in public repositories. Kelley will work with an undergraduate student, either as a senior capstone project or a summer REU project. This mentorship experience will include instruction in sample preparation, hands-on data collection at the Advanced Photon Source, and the opportunity to present research results at an international meeting. Nelson will recruit an undergraduate for the project duration to participate in sample preparation, Re, Os, and PGE extraction in a clean-lab, and data collection for a senior project. This student also will have the opportunity to present results at an international meeting. Kelley will also incorporate drilling results into undergraduate and graduate courses at URI/GSO (e.g., OCG 540 Marine Geology; OCG 110 The Ocean Planet).

Results from Prior Support

Reagan: EAR 0840862 MARGINS: Mariana forearc geology and early arc volcanism, 2/1/09-1/31/14, M.K. Reagan (with D.W. Peate and W.C. McClelland) $ 153,613.

Intellectual Merit: A primary goal of the project was to develop a better understanding of subduction initiation and early arc development in the western Pacific by generating geochemical and geochronological data for early arc volcanism in the Izu-Bonin-Mariana (IBM) arc. We discovered that the most abundant igneous rock throughout the IBM forearc is basalt (i.e. "fore-arc basalts" or FAB) related to subduction initiation at 51-52 Ma (Reagan et al., 2010; Ishizuka et al., 2011; Reagan et al., 2013; Ishizuka et al., 2014). Another result was a confirmation that the geology of the IBM "naked" fore-arc (Stern et al., 2012) resembles that of many ophiolites. The transition from FAB to boninite was shown to take about 3-4 million years, and the transition normal arc volcanism was shown to take about 7 million years. We discovered a new serpentine-hosted ecosystem that was documented in ref. (Ohara et al., 2012). We suggested that the similarity of the IBM stratigraphy with that of the Nuvvuagittuq terrane (Turner et al., 2014), Quebec is consistent with rudimentary subduction beginning in the Hadean. This paper also speculated that early subduction zones would have been ideal locations for the development of early life. Finally, rapid evolution of magma source fO_2 after subduction initiation in the IBM arc was documented in ref. (Brounce et al., in press). *Broader Impacts:* Results from this study provided crucial background for IODP Expedition 352. This work fostered fruitful collaboration between Japanese and US scientists involved with several dive cruises of the RV Yokosuka/Shinkai 6500. The project also supported graduate and undergraduate student research. Publications from this this grant are listed in the references list and marked with "+".

Katherine A. Kelley: EAR-0841108, Collaborative Research: The Oxidation State of Mariana Arc Magmas and its Relationship to Subduction Volatile and Mass Cycling (w/ E. Cottrell), 03/01/2009-02/28/2015, $277,254.

Intellectual Merit: This study conducted comprehensive analyses of $Fe^{3+}/\sum Fe$ ratios in experimental and natural glasses, as a proxy for the oxygen fugacity of primitive arc and back-arc basin magmas in the Mariana arc. Examination of a global suite of basalt glasses and melt inclusions shows that $Fe^{3+}/\sum Fe$ increases with magmatic H_2O and Ba/La ratio, linking the hydrous mass flux from the subducted plate with oxidation (Kelley & Cottrell, 2009; Brounce et al., 2014). The differentiation of a single arc magma, as preserved by melt inclusions, shows a trend towards reduction as the magma crystallizes and degasses, which is empirically linked to sulfur loss to the vapor during degassing (Kelley & Cottrell, 2009). Other findings show that the modern Mariana arc magmas are oxidized roughly proportional to their Ba/La ratios (60), and that mantle wedge oxidation takes place within the first few Ma of subduction initiation (Brounce et al., in press). *Broader Impacts:* Work of PhD student Maryjo Brounce aimed to characterize the redox conditions of magmas from all Mariana arc volcanoes, using melt inclusion analyses. Brounce gained proficiency in melt inclusion sample preparation and XANES, FTIR, EMP, and LA-ICP-MS analytical methods. Brounce completed her PhD in 2014 and is now a post-doctoral fellow at Caltech; she is pursuing an academic career in the geosciences. Overall, this project produced 7 peer-reviewed publications that are indicated by * in the reference list.

Shervais: Collaborative Research: Geochemical Processes in Forearc Peridotites: Depletion, Enrichment, and Melt Reactions in the Mantle Wedge [9/05-8/08]
NSF EAR-440255 (Shervais: $85,949 USU budget); EAR-0440238 (Mukasa)
Intellectual Merit: We analyzed peridotites of the Coast Range Ophiolite, California that document hydrous partial melting and extreme melt extraction that began in the garnet stability field and progressed into the spinel field, using whole rock chemistry and mineral chemistry by EMPS and LA-ICPMS). Most CRO peridotites represent supra-subduction mantle that has experienced extreme melt depletion; abyssal peridotites are rare. LREE and high-field strength elements are extremely low, but fluid mobile elements (FME) such as B, Li, Rb, and Pb are strongly enriched. Melt models for the SSZ peridotites require 15-29% melt extraction that began in the garnet stability field and progressed into the spinel field, with continuous enrichment of FME and a melt phase. The combination of FME and melt enrichment, super-imposed on extreme melt extraction, is confirmed by isotopic analyses of ultra-pure Cpx separates which show radiogenic Hf, Pb, Sr, and Nd. We derived an algorithm that calculates the concentration of FME in the fluid flux during melting using LA-ICPMS data for pyroxene.*Broader Impacts:* This project supported the work of a female post-doc (Sung-Hi Choi) at the University of Michigan, and an Hispanic PhD student (Marlon Jean) at Utah State University; Choi is now a faculty member at Chungnam National University (Korea) and Jean is a Humboldt Post-Doctoral Fellow at the Leibniz Universität Hannover. This project resulted in 8 peer reviewed publications, indicated by † in References.

Jeff Ryan: *DUE 1323275 - Collaborative: Expanding the Use of Online Remote Electron Microscopy in the Classroom to Transform Undergraduate Geoscience Education ($161,000 to USF ; DUE 1323419 - Collaborative: Google Earth in Onsite and Distance Education (GEODE)($45100 to USF).*

Intellectual Merit: These NSF-TUES projects expand the use of effective curricular practices toward improving undergraduate courses and engaging students in undergraduate research, through in-class analytical experiences with electron microprobe/SEM, and via classroom interrogation geo-data repositories. *Broader Impacts:* These projects established new institutional partnerships, and engaged with >100 teaching faculty at a range of institutional types. These projects have thus far generated two publications (marked with ** in the References) and several online teaching activities (http://serc.carleton.edu/NAGTWorkshops/geochemistry/activities/46409.html; http://serc.carleton.edu/NAGTWorkshops/undergraduate_research/research_prep.html; http://serc.carleton.edu/NAGTWorkshops/undergraduate_research/cyberinfrastructure.html; http://serc.carleton.edu/NAGTWorkshops/undergraduate_research/casestudy/electron_microprobe.html).

W. Nelson - no prior NSF support

References

Agostini, S., Ryan, J.G., Tonarini, S., Innocenti F. (2008) Drying and dying of a subducted slab: Coupled Li and B isotope variations in Western Anatolia Cenozoic volcanism. Earth Planet. Sci. Lett. 272, 139-147.

Bebout, G.E., Ryan, J.G., Leeman, W.P., Bebout, A.E. (1999) Fractionation of trace elements by subduction zone metamorphism: significance for models of crust-mantle mixing. Earth Planet. Sci. Lett. 177, 69-83.

Benton, L., Ryan, J.G., Savov I. (2004) Lithium abundance and isotope systematics of forearc serpentinites, Conical Seamount, Mariana forearc: Insights into the mechanisms of slab/mantle exchange during subduction. Geochem. Geophys. Geosyst. 5, 10.1029/2004GC000708.

Bizimis, M., Griselin, M., Lassiter, J.C., Salters, V.J.M., Sen, G. (2007) Ancient recycled mantle lithosphere in the Hawaiian plume: Osmium-Hafnium isotopic evidence from peridotite mantle xenoliths. Earth Planet. Sci. Lett., 257, 259-273.

Bloomer, S.H. (1983) Distribution and origin of igneous rocks from the landward slopes of the Mariana Trench: Implications for its structure and evolution. J. Geophys. Res. 88, 7411-7428.

*Brounce, M. N., K. A. Kelley, E. Cottrell (2014) Variations in $Fe^{3+}/\sum Fe$ of Mariana Arc Basalts and Mantle Wedge fO_2, J. Petrol. 55, 2513-2536, doi:10.1093/petrology/egu065.

*+Brounce, M., Kelley, K.A., Cottrell, E., Reagan, M.K. (in press) Temporal evolution of mantle wedge oxygen fugacity during subduction initiation. Geology, doi:10.1130/G36742.1.

†Choi, S.H., Shervais, J.W., Mukasa, S.B (2008a) Supra-Subduction and Abyssal Mantle Peridotites of the Coast Range Ophiolite, California, Contrib. Mineral. Petrol. 155, 551 - 576.

†Choi, S.H., Shervais, J.W., Mukasa, S.B. (2008b) Initiation of Franciscan Subduction along a Large-offset Fracture Zone: Evidence from Mantle Peridotites, California, California, Geology, 36, 595-598. doi: 10.1130/G24993A.1.

*Cottrell, E., K. A. Kelley (2011) The oxidation state of Fe in MORB glasses and the oxygen fugacity of the upper mantle, Earth Planet. Sci. Lett., 305, 270-282.

*Cottrell, E., K. A. Kelley (2013) Redox Heterogeneity in Mid-Ocean Ridge Basalts as a Function of Mantle Source. Science, 340, 1314-1317, doi:10.1126/science.1233299.

*Cottrell, E., K. A. Kelley, A. T. Lanzirotti, R. A. Fischer (2009) High-precision determination of iron oxidation state in silicate glasses using XANES, Chem. Geol., 268, 167-179.

Crawford, A.J., Falloon, T.J., Green, D.H. (1989) Classification, petrogenesis and tectonic setting of boninites. In Crawford, A.J. (Ed.), Boninites and Related Rocks: London (Unwin Hyman), 1–49.

Dale, C.W., Luguet, A., MacPherson, C.G., Pearson, D.G., Hickey-Vargas, R. (2008) Extreme platinum-group element fractionation and variable Os isotope compositions in Philippine Sea Plate basalts: Tracing mantle source heterogeneity. Chemical Geology, 248, 213-238.

Dauphas, N., Roskosz, M., Alp, E. E., Neuville, D. R., Hu, M. Y., Sio, C. K., Tissot, F. L. H., Zhao, J., Tissandier, L., Médard, E., Cordier C. (2014) Magma redox and structural controls on iron isotope variations in Earth's mantle and crust, Earth Planet. Sci. Lett., 398, 127-140.

DeBari, S.M., Taylor, B., Spencer, K., Fujioka, K. (1999) A trapped Philippine Sea plate origin for MORB from the inner slope of the Izu-Bonin Trench. Earth Planet. Sci. Lett., 174, 183–197.

Dilek, Y., Flower, M.F.J. (2003) Arc-trench rollback and forearc accretion, 2. A model template for ophiolites in Albania, Cyprus, and Oman. In Dilek, Y., and Robinson, R.T. (Eds.), Ophiolites in Earth History. Geol. Soc. Spec. Publ., 218, 43–68.

Dixon E. J., Stolper E. M. and Holloway J. R. (1995) An experimental study of water and carbon dioxide solubilities in mid-ocean ridge basaltic liquids: Part I. Calibration and solubility models. J. Petrol. 36, 1607–1631.

Eiler, J.M., Carr, M.J., Reagan, M., Stolper, E. (2005) Oxygen isotope constraints on the sources of Central American arc lavas. Geochem. Geophys. Geosys. - G36: 28.

Expedition 352 Scientists (2015) Izu-Bonin-Mariana fore arc: Testing subduction initiation and ophiolite models by drilling the outer Izu-Bonin-Mariana fore arc. International Ocean Discovery Program Preliminary Report, 352. http://dx.doi.org/10.14379/iodp.pr.352.2015.

Gale, A., Dalton, C.A., Langmuir, C.H., Su, Y., Schilling, J-G. (2013) The mean composition of ocean ridge basalts. Geochem. Geophys. Geosys., G314, 489-518.

Gale, A., Langmuir, C.H., Dalton, C.A. (2014) The Global Systematics of Ocean Ridge Basalts and their Origin. J. Petrol. 55, 1051-1082.

Gerya, T.V. (2014) Precambrian geodynamics; concepts and models. Gondwana Res. 25, 442-463.

Hattori K.H., Guillot, S., (2007) Geochemical character of serpentinites associated with high- to ultrahigh-pressure metamorphic rocks in the Alps, Cuba, and the Himalayas: Recycling of elements in subduction zones. Geochem., Geophys., Geosyst. 8, Q09010. http://dx.doi.org/10.1029/2007GC001594.

Hawkesworth, C.J., Kemp, A.I.S. (2006) The differentiation and rates of generation of the continental crust. Chem. Geol. 226, 134-143.

Hickey-Vargas, R. Reagan, M. K. (1987) Temporal variation of isotope and rare earth element abundances in volcanic rocks from Guam; implications for the evolution of the Mariana arc. Contrib. Mineral. Petrol. 97, 497-508.

Ishikawa, T. Nakamura, E. (1992) Precise boron isotopic analysis of natural rock samples using a boron-mannitol complex. Chemical Geology, 94, 193-204.

Ishizuka, O., Kimura, J.-I., Li, Y.B., Stern, R.J., Reagan, M.K., Taylor, R.N., Ohara, Y., Bloomer, S.H., Ishii, T., Hargrove, U.S., III, Haraguchi, S. (2006) Early stages in the evolution of Izu-Bonin arc volcanism: new age, chemical, and isotopic constraints. Earth Planet. Sci. Lett., 250, 385–401.

+Ishizuka, O., Tani, K., Reagan, M.K., Kanayama, K., Umino, S., Harigane, Y., Sakamoto, I., Miyajima, Y., Yuasa, M., Dunkley, D.J., 2011. The timescales of subduction initiation and subsequent evolution of an oceanic island arc. Earth Planet. Sci. Lett. 306, 229–240.

+Ishizuka, O., Tani, K., Reagan, M.K. (2014) Izu-Bonin-Mariana fore-arc crust as a modern ophiolite analogue. Elements, 10, 115-120.

Jackson, M.G., Shirey, S.B. (2011) Re-Os isotope systematics in Samoan shield lavas and the use of Os-isotopes in olivine phenocrysts to determine primary magmatic compositions. Earth Planet. Sci. Lett. 312, 91-101.

†Jean, M.M., Shervais, J.W., Choi, S.H., Mukasa, S.B. (2010) Melt Extraction and Melt Refertilization in Mantle Peridotite of the Coast Range Ophiolite: An LA-ICP-MS Study, Contrib. Mineral. Petrol. 159, 113-136, doi:10.1007/s00410-009-0419-0.

Jenner, F.E., O'Neill H.St.C. (2012) Analysis of 60 elements in 616 ocean floor basaltic glasses. Geochem. Geophys. Geosyst. 13, Q02005. doi: 10.1029/2011GC004009.

Johnson, L.E., Fryer, P. (1990) The first evidence for MORB-like lavas from the outer Mariana forearc: geochemistry, petrography and tectonic implications. Earth Planet. Sci. Lett., 100, 304-316.

Kimura, J-I., Hacker, B.R., van Keken, P.E., Kawabata, H., Yoshida, T., et al. (2009) Arc Basalt Simulator version 2, a simulation for slab dehydration and fluid-fluxed mantle melting for arc basalts: Modeling scheme and application. Geochem., Geophys., Geosyst. 10, Q09004, doi:10.1029/2008GC002217.

*Kelley, K. A., Cottrell, E. (2009) Water and the oxidation state of subduction zone magmas, Science, 325, 605-607, doi:10.1126/science.1174156.

*Kelley, K. A., Cottrell, E. (2012) The influence of magmatic differentiation on the oxidation state of Fe in a basaltic arc magma, Earth Planet. Sci. Lett., 329-330, 109-121, doi:10.1016/j.epsl.2012.02.010.

Kress, V. C., Carmichael, I. S. E. (1991) The compressibility of silicate liquids containing Fe_2O_3 and the effect of composition, temperature, oxygen fugacity and pressure on their redox states. Contrib. Mineral. Petrol. 108, 82-92.

Langmuir, C.H., Bender, J.F., Batiza, R. (1986) Petrological and Tectonic segmentation of the East Pacific Rise 5o 30’-14° 30’ N. Nature, 322, 422-429.

Le Bas, M.J. (2000) IUGS Reclassification of the High-Mg and Picritic Volcanic Rocks**.** J. Petrology 41, 1467-1470, doi:10.1093/petrology/41.10.1467.

Lee, C-T. A. Luffi, P., Plank, T., Dalton, H., Leeman, W.P. (2009) Constraints on the depths and temperatures of basaltic magma generation on Earth and other terrestrial planets using new thermobarometers for mafic magmas. Earth Planet. Sci. Lett. 279, 20-33.

Marschall, H.R., Monteleone, B.D. (2015) Boron isotope analysis of silicate glass with very low boron concentrations by secondary ion mass spectrometry. Geostand. and Geoanal. Res., 39, 31-46.

Meijer, A. (1980) Primitive arc volcanism and a boninite series; example from western Pacific Island arcs, in *The Tectonic and Geologic Evolution of Southeast Asian Seas and Islands,* Geophys. Monogr. Ser., edited by D. E. Hayes, 23, 269–282.

Meisel, T., Walker, R.J., Irving, A.J., Lorand, J.-P. (2001) Osmium isotopic compositions of mantle xenoliths: A global perspective. Geochim. Cosmochim. Acta, 65, 1311-1323..

†Metcalf, R.V., Shervais, J.W. (2008) Supra-Subduction Zone (SSZ) Ophiolites: Is There Really An "Ophiolite Conundrum"?, in James E. Wright and John W. Shervais, editors, Ophiolites, Arcs, and Batholiths: Geological Society of America Special Paper 438, 191–222, doi: 10.1130/2008.2438(07).

Métrich, N., Deloule, E. (2014) Water content, delta D and delta ^{11}B tracking in the Vanuatu Arc magmas (Aoba Island); insights from olivine-hosted melt inclusions. Lithos, 206-207:400-408.

Newman, S., Stolper, E., Stern, R. (2000) H_2O and CO_2 in magmas from the Mariana arc and back arc systems. Geochem. Geophys. Geosyst. 1, 1999GC000027.

Noll, P.D., Newsom, H.E., Leeman, W.P., Ryan, J.G. (1996) The role of hydrothermal fluids in the production of subduction zone magmas: evidence from siderophile and chalcophile trace elements and boron. Geochim. Cosmochim. Acta. 60, 587-611.

+Ohara,Y., Reagan, M.K., Fujikura, K., Watanabe., H., Michibayashi, K., Ishii, T., Stern, R.J., Pujana, J.I., Martinez, F., Girard, G., Ribeiro, J., Brounce, M., Naoaki K., Kino, M. (2012) A serpentinite-hosted ecosystem in the Southern Mariana Forearc. Proceedings of the National Academy of Sciences. PNAS, 109, 2831–2835.

Parkinson, I.J., Hawkesworth, C.J., Cohen, A.S. (1998) Ancient mantle in a modern arc: osmium isotopes in Izu-Bonin-Mariana forearc peridotites. Science, 281, 2011–2013.

Parman, S.W., Grove T.L. (2004) Harzburgite melting with and without H2O: Experimental data and predictive modeling, J. Geophys. Res., 109, B02201, doi:10.1029/2003JB002566.

Pearce, J.A., Robinson, P.T. (2010) The Troodos ophiolitic complex probably formed in a subduction initiation, slab edge setting. Gondwana Res. 18, 60–81.

Pearce, J.A., Kempton, P.D., Nowell, G.M., Noble, S.R. (1999) Hf-Nd element and isotope perspective on the nature and provenance of mantle and subduction components in western Pacific arc-basin systems. J. Petrol. 40, 1579–1611.

Pearce, J.A., van der Laan, S.R., Arculus, R.J., Murton, B.J., Ishii, T., Peate, D.W., Parkinson, I.J. (1992) Boninite and harzburgite from Leg 125 (Bonin-Mariana forearc): a case study of magma genesis during the initial stages of subduction. In Fryer, P., Pearce, J.A., Stokking, L.B., et al., 1992. Proc. ODP, Sci.

Results, 125, 623–659.

Petersen, J. (1891) Der Boninit von Peel Island. Jahrb. Hamburg Wiss. Anst. 8, 314-349.

Putirka, K.D. (2008) Thermometers and barometers for volcanic systems, in: Putirka, K. D., and Tepley, F. eds., Rev. Mineral. Geochem. 69, 61-120.

Reagan, M.K., Hanan, B.B., Heizler, M.T., Hartman, B.S., Hickey-Vargas, R. (2008) Petrogenesis of volcanic rocks from Saipan and Rota, Mariana Islands, and implications for the evolution of nascent island arcs. J. Petrol. 49, 441–464.

+Reagan, M.K., Ishizuka, O., Stern, R.J., Kelley, K.A., Ohara, Y., Blichert-Toft, J., Bloomer, S.H., Cash, J., Fryer, P., Hanan, B.B., Hickey-Vargas, R., Ishii, T., Kimura, J-I., Peate, D.W., Rowe, M.C., Woods, M. (2010) Fore-arc basalts and subduction initiation in the Izu-Bonin-Mariana system. Geochem., Geophys., Geosyst., 11, Q03X12. doi:10.1029/2009GC002871.

+Reagan, M.K., McClelland, W.C., Girard, G., Goff, K.R., Peate, D.W., Ohara, Y., Stern, R.J. (2013) The geology of the southern Mariana fore-arc crust: implications for the scale of Eocene volcanism in the western Pacific. Earth Planet. Sci. Lett., 380, 41–51.

**Ryan, J.G. (2013) Chapter 8: Integration of Research into the Classroom and Curriculum, in Schuh, M, (ed.) *Starting out in Undergraduate Research,* Council on Undergraduate Research, Washington, DC, pp. 44-49.

**Ryan, J.G., (2013) Embedding research practice activities into earth and planetary science courses through the use of remotely operable analytical instrumentation: interventions, and impacts on student perceptions and activities. In Tong, V. (ed). *Geoscience Research and Education: Teaching at Universities*. New York, Springer Verlag., 149-162.

Ryan, J.G. Langmuir C.H. (1987) The systematics of lithium abundances in young volcanic rocks. Geochim. Cosmochim. Acta 51, 1727-1741.

Ryan, J.G. Langmuir C.H. (1993) The systematics of boron abundances in young volcanic rocks. Geochimica Cosmochimica Acta 57, 1489-1498.

Ryan, J.G. Kyle, P.R. (2004) Lithium and lithium isotope variations in intraplate mantle sources: insights from McMurdo Group lavas (Mt. Erebus) and other intraplate volcanic rocks. Chemical Geology, 212, 125-142.

Ryan, J.G., Leeman, W.P., Morris, J.D. Langmuir, C.H. (1996) The boron systematics of intraplate lavas: implications for crust and mantle evolution. Geochimica et Cosmochimica Acta. 60, 415-422.

Savov, I.P., Ryan, J.G., D'Antonio, M., Fryer P. (2007) Petrology and geochemistry of serpentinized peridotites from Mariana Forearc, South Chamorro Seamount, ODP Leg 195: Implications for the elemental recycling across and along the Mariana arc-basin system. Journal of Geophysical Research, 112, doi:10.1029/2006JB004749.

Savov, I.P., Ryan, J.G., Kelley, K., Mattie, P.D. (2005) Geochemistry of serpentinites from the Mariana Forearc- Conical Seamount, ODP Leg 125: describing fluid-mediated slab additions. Geochem., Geophys., Geosyst., 6, Q04J15 DOI10.1029/2004GC000777.

Shervais, J.W. (1982) Ti–V plots and the petrogenesis of modern and ophiolitic lavas. Earth Planet. Sci. Lett. 59, 101–118.

†Shervais, J.W., Kolesar, P., Andreasen, K. (2005) Field and Chemical Study of Serpentinization, Stonyford, California: chemical flux & mass balance, International Geology Review 47, 1-23.

†Shervais, J,W. Jean, M.M. (2012) Inside the Subduction Factory: Fluid mobile trace elements in the mantle wedge above a subduction zone, Geochim. Cosmochim. Acta 95, 270-285.doi:10.1016/j.gca.2012.07.006

†Shervais, J.W., Choi, S-H. (2012) Subduction Initiation along Transform Faults: Initiation of the proto-

Franciscan subduction zone. Lithosphere 4, 484-496, doi:10.1130/L153.

†Shervais, J.W., Choi, S-H., Sharp, W.D., Ross, J., Zoglman-Schuman, M.M., Mukasa, S.B. (2011) Serpentinite Matrix Mélange: Implications of Mixed Provenance for Mélange Formation. In Wakabayashi, J. and Dilek, Y., eds, Melanges: Processes of Formation and Societal Significance, Geological Society of America Special Paper 480, 1-38.

Standish J. J., Hart, S. R., Blusztajn, J., Dick, H. J. B., Lee K. L. (2002) Abyssal peridotite osmium isotopic compositions from Cr-spinel. Geochem. Geophys. Geosys. 3, 10.1029/2001GC000161.

Stern, R.J. (2005) Evidence from ophiolites, blueschists, and ultrahigh-pressure metamorphic terranes that the modern episode of subduction tectonics began in Neoproterozoic time. Geology 33, 557-560.

Stern, R.J., Bloomer, S.H. (1992) Subduction zone infancy: examples from the Eocene Izu-Bonin-Mariana and Jurassic California Arcs. Geol. Soc. Am. Bull. 104, 1621–1636.

+Stern, R.J., Reagan, M.K., Ishizuka, O., Ohara, Y., Whattam, S. (2012) To Understand Subduction Initiation, Study Forearc Crust; To Understand Forearc Crust, Study Ophiolites. Lithosphere 4, 469-483.

Straub, S.M. Layne, G.D. (2002) The systematics of boron isotopes in Izu arc front volcanic rocks. Earth Planet. Sci. Lett. 198, 25–39.

Sun, S.S., McDonough, W.F. (1989) Chemical and isotopic systematics of oceanic basalts; implications for mantle composition and processes, in Magmatism in the Ocean Basins, edited by A. D. Saunders, Geol. Soc. Spec. Publ., 42, 313–345.

Suzuki, K., Senda, R., Shimizu, K. (2011) Osmium behavior in a subduction system elucidated from chromian spinel in Bonin Island beach sands. Geology, 39, 999-1002.

Tanaka, R., Nakamura. E. (2005) Boron isotope constraints on the source of Hawaiian shield lavas. Geochim. Cosmochim. Acta, 69, 3385-3399.

Taylor, R.N., Nesbitt, R.W. (1998) Isotopic characteristics of subduction fluids in an intra-oceanic setting, Izu-Bonin Arc, Japan. Earth Planet. Sci. Lett., 164, 79-98.

Taylor, R.N., Nesbitt, R.W., Vidal, P., Harmon, R.S., Auvray, B., Croudace, I.W. (1994) Mineralogy, chemistry, and genesis of the Boninite Boninite Series Volcanics, Chichijima, Bonin Islands, Japan. J. Petrol. 35, 577.

Taylor, S.R., McLennan, S.M. (1995) The geochemical evolution of the continental crust. Rev. Geophys. 33, 241-265.

Tomascak, P. Ryan, J.G., Defant M.J. (2000). Lithium isotopes and light elements depict incremental slab contributions to the subarc mantle in Panama. *Geology*, 28, 507-510.

Tomascak, P.B., Widom, E., Benton, L. D., Goldstein, S.J., Ryan, J. G. (2002) The control of Lithium Budgets in Island Arcs. Earth Planet. Sci. Lett. 196, 227-238.

Turner, M., Ireland, T., Hermann, J., Holden, P., Padr´on-Navarta, J.A., Hauri, E.K., Turner S. (2015) Sensitive high resolution ion microprobe – stable isotope (SHRIMP-SI) analysis of water in silicate glasses and nominally anhydrous reference minerals. J. Analy. At. Spectr. 30, 1681–1830.

+Turner, S., Rushmer, T., Reagan, M., Moyen, J-F. (2014) Heading down early on? Start of subduction on Earth. Geology 42, 139-142.

Umino, S. (1985) Volcanic geology of Chichijima, the Bonin Islands (Ogasawara Islands) J. Geol. Society of Japan 91, 505-523.

Uppstrom, L. R. (1974) The boron/chlorinity ratio of deep-sea water from the Pacific Ocean. Deep-Sea Res. 21, 161-162.

van Hunen, J., Moyen, J-F. (2012) Archean subduction; fact or fiction? Ann. Rev. Earth and Planet. Sci. 40:195-219.

Wade, J.A., Plank, T., Hauri, E.H., Kelley, K.A., Roggensack K., Zimmer, M. (2008) Prediction of magmatic water contents via measurement of H2O in clinopyroxene phenocrysts. Geology 36, 799-802.

Warren, J M, Shirey, S B. (2012) Lead and osmium isotopic constraints on the oceanic mantle from single abyssal peridotite sulfides. Earth Planet. Sci. Lett., 359-360: 279-293.

Whattam, S.A., Stern, R.J. (2011) The 'subduction initiation rule': a key for linking ophiolites, intra-oceanic forearcs, and subduction initiation. Contrib. Mineral. Petrol. 162,1031-1045.

Woodhead, J.D., Hergt, J.M., Davidson, J.P., Eggins, S.M. (2001) Hafnium isotope evidence for "conservative" element mobility during subduction zone processes. Earth Planet. Sci. Lett., 192, 331-346.

Workman, R.K., Hart, S.B. (2005) Major and trace element composition of the depleted MORB mantle (DMM). Earth Planet. Sci. Lett. 231, 53-72.

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Professional Preparation

University of California, Santa Barbara, California, 1975-1978, B.A. Geology with High Honors, March 1978.

University of Arizona, Tucson, Arizona, 1979-1982, M.S. Geology, May 1982.

University of California, Santa Cruz, California, 1982-1987, Ph.D. Geology, September 1987.

Academic Appointments

Professor, 2014-2015, Department of Earth & Environmental Sciences, University of Iowa.

Department Executive Officer and Professor, 2009-2014, Department of Earth & Environmental Sciences, University of Iowa, Iowa City.

Professor, 2007-2009, Department of Geoscience, University of Iowa.

Associate Professor, 1995-2007, Department of Geoscience, University of Iowa.

Assistant Professor, 1987-1995, Department of Geology, University of Iowa.

Products closely related to the proposed project

Brounce, M., Kelley, K.A., Cottrell, E., and Reagan, M.K., in press, Temporal evolution of mantle wedge oxygen fugacity during subduction initiation. *Geology*.

Ishizuka, O., Tani, K., Reagan, M.K., 2014, Izu-Bonin-Mariana fore-arc crust as a modern ophiolite analogue. *Elements*, v. 10, p. 115-120.

Turner, S., Rushmer, T., Reagan, M., Moyen, J-F., 2014, Heading down early on? Start of subduction on Earth. *Geology*, v. 42, p. 139-142

Reagan, M.K., McClelland, W.C. Girard, G., Goff, K.R., Peate, D.W., Ohara, Y., & Stern, R.J., 2013, The geology of the southern Mariana fore-arc crust: implications for the scale of Eocene volcanism in the western Pacific. *Earth and Planetary Science Letters*, v. 380, p. 41-51.

Reagan, M.K., Ishizuka, O., Stern, R.J., Kelley, K.A., Ohara, Y., Blichert-Toft, J., Bloomer, S.H., Cash, J., Fryer, P., Hanan, B., Hickey-Vargas, R., Ishii, T., Kimura, J-I., Peate, D.W., Rowe, M.C., and Woods, M., 2010, Fore-arc basalts and subduction initiation in the Izu-Bonin-Mariana system. *Geochemistry Geophysics Geosystems.* v. 11, doi: 10.1029/2009GC002871, 17 pp.

Five other significant products

Turner, M.B. Reagan, M.K., Turner, S.P., Sparks, R.S.J., Handley, H.K., Girard, G., Suh C.E., 2013, Volatile fluxing and eruption explosivity – insights from U-series disequilibria at Mount Cameroon, West Africa. *Journal of Volcanology and Geothermal Research*, v. 262, p. 38-46.

Stern, R.J., Reagan, M.K., Ishizuka, O., Ohara, Y., and Whattam, S., 2012, To Understand Subduction Initiation, Study Forearc Crust; To Understand Forearc Crust, Study Ophiolites. *Lithosphere* v. 4 p. 469-483.

Ohara,Y., Reagan, M.K., Fujikura, K., Watanabe., H., Michibayashi, K., Ishii, T., Stern, R.J., Pujana, J.I., Martinez, F., Girard, G., Ribeiro, J., Brounce, M., Naoaki K., and Kino, M., 2012, A serpentinite-hosted ecosystem in the Southern Mariana Forearc. *Proceedings of the National Academy of Sciences*. PNAS, v. 109 p. 2831–2835.

Ishizuka, O., Tani, K., Reagan, M.K., Kanayama, K., Umino, S., Harigane, Y., Sakamoto, I., Miyajima, Y., Yuasa, M., Dunkley, D.J., 2011, The timescales of subduction initiation and subsequent evolution of an oceanic island arc. *Earth and Planetary Science Letters*, v. 306 p. 229-240.

Reagan, M.K., Hanan, B.B., Heizler, M.T., Hartman, B.S., Hickey-Vargas, R., 2008, Petrogenesis of volcanic rocks from Saipan and Rota, Mariana Islands and implications for the evolution of nascent island arcs. *Journal of Petrology*. v. 49, p. 441-464.

Synergistic Activities

I recently stepped down as Department Executive Officer, where I promoted installation of classrooms and pedagogical methods to enhance learning in geoscience courses. I helped develop chemical separation and counting techniques for analyzing short-lived U-series nuclides. I was a member of the MARGINS Steering Committee, and participated in most GeoPRISMS workshops since its inception. I am a member of the IEDA User Group. I have been involved in developing proposals and workshops associated with drilling in the IBM subduction system, culminating in my co-chief scientist position on IODP expedition 352.

Recent Collaborators

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Graduate Advisors

(2) James Gill, University of California, Santa Cruz (Emeritus)
Arend Meijer, Tucson, Arizona, (retired)

Graduate and Postdoc Advisees

(12) Guillaume Girard (MSU), Jennifer Garrison, (Cal.State LA), Daniel Feuerbach (ExxonMobil), Eileen Herrstrom (U.Illinois), Huijuan Zou (Yale), Jennifer Thompson (U.Tasmania), Matthew Wortel (U.Iowa), Brian Hartman (Hudbay), Jennifer Weber (ExxonMobil), Mary Sue Bell (Johnson Space Center), Scott Clark (Wisc. Eau Claire), Jeff Dorale (U.Iowa)

BIOGRAPHICAL SKETCH

Jeffrey G. Ryan

Department of Geology, University of South Florida
4202 East Fowler Ave. Tampa, Florida 33620
Phone: (813) 974-1598/6492 **FAX:** (813) 974-2654 **Email:** ryan @ mail.usf.edu

Education and Post-Doctoral Experience:

1983: B.S. (Summa Cum Laude), Geology, Western Carolina University
1985; 1987;1989: M.A., M. Phil., Ph.D., Columbia University. Thesis Title: The Systematics of Lithium, Beryllium and Boron in Young Volcanic Rocks. Advisor: C.H. Langmuir
1989-1991: Postdoctoral Fellow, Department of Terrestrial Magnetism, Washington, DC.

Professional History:

2002-Present Professor, Department of Geology, University of South Florida
2013-2015 Chair and Director, School of Geosciences, University of South Florida
2000-2001; 2009-2013 Chair, Department of Geology, University of South Florida
2005-2009 Assistant Chair, Department of Geology, University of South Florida
2003-2005 Program Director, EHR/DUE, National Science Foundation
1991-2002 Assistant (to 1996), Associate Professor, Dept. Geology, Univ. South Florida

Five Relevant Publications (students in **Bold**):

Ryan, J.G. and Chauvel, C., (2013), "The Subduction Zone Conveyor and the Impact of Recycled Materials on the Evolution of the Mantle." Chapter 3.13: (Carlson, R.W., ed.) *Treatise on Geochemistry, Second Edition: Volume 3: The Mantle and Core.* pp. 479-508.

Agostini, S., Tonarini, S., Ryan, J.G., and Innocenti, F. (2008) Drying and dying of a subducted slab: Li and B isotope variations in Western Anatolia Cenozoic Volcanism. *Earth and Planetary Science Letters*, v. 272; 139-147.

Savov, I.P., Ryan, J.G., D'Antonio, M. and P. Fryer (2007) Petrology and geochemistry of serpentinized peridotites from Mariana Forearc, South Chamorro Seamount, ODP Leg 195: Implications for the elemental recycling across and along the Mariana arc-basin system. *Journal of Geophysical Research*, v. 112, doi:10.1029/2006JB004749.

Savov, I.P., R. Hickey- Vargas, M. D'Antonio, and J.G. Ryan, (2005) Petrology and Geochemistry of West Philippine Back-arc Basin Basalts and Early Palau-Kyushu Arc volcaniclasts from ODP Leg 195, Site 1201:Implications for the evolution of the Izu- Bonin-Mariana subduction factory. *Journal of Petrology*:10.1093/petrology/egi075.

Savov, I.P., Ryan, J.G., Kelley, K. and **Mattie, P.D.** (2005) Geochemistry of serpentinites from the Mariana Forearc- Conical Seamount, ODP Leg 125: describing fluid-mediated slab additions. *Geochemistry, Geophysics, Geosystems,* 6, Q04J15 DOI10.1029/2004GC000777.

Other Relevant Publications:

Ryan, J.G., (2013) Embedding research practice activities into earth and planetary science courses through the use of remotely operable analytical instrumentation: interventions, and impacts on student perceptions and activities. In Tong, V. (ed). *Geoscience Research and Education: Teaching at Universities*. New York, Springer Verlag., p. 149-162.

Walker, J.A., A. Teipel, J.G. Ryan, and E. Syracuse (2009) Light elements and Li isotopes across the northern portion of the Central American subduction zone. *Geochemistry, Geophysics, Geosystems*, v. 10, Q06S16, doi:10.1029/2009GC002414

Benton, L., J.G. Ryan, and **I. Savov** (2004) Lithium abundance and isotope systematics of forearc serpentinites, Conical Seamount, Mariana forearc: Insights into the mechanisms of slab/mantle exchange during subduction. *Geochemistry, Geophysics, Geosystems,* v.5, 10.1029/2004GC000708.

Ryan, J.G. and Kyle, P.R. (2004) Lithium and lithium isotope variations in intraplate mantle sources: insights from McMurdo Group lavas (Mt. Erebus) and other intraplate volcanic rocks. *Chemical Geology*, v. 212, pp 125-142.

Bebout, G.E., Ryan, J.G., Leeman, W.P., and Bebout, A.E. (1999) Fractionation of trace elements by subduction zone metamorphism: significance for models of crust-mantle mixing. *Earth and Planetary Science Letters*, 177, 69-83.

Synergistic Activities:

NSF Education Projects: Active NSF educational projects include: “Expanding the Use of Online Remote Electron Microscopy in the Classroom to Transform Undergraduate Geoscience Education,” “Google Earth for Onsite and Distance Education,” “Faculty Development to Support High Impact Activities That Transform Undergraduate Geoscience Education (TUES); “USF Robert Noyce Scholarship Program (Noyce); CACCE Partnership (CCEP); PI and Convener, NSF-NSDL supported Workshop: “Planning the Future of Geo-Cybereducation”, 1/10; PI on a half-dozen past CCLI, REU and CCEP Program grant awards, and two REU Supplements; Planning committee, Summit Meeting on the Future of Undergraduate Geoscience Education (1/10-12/14, Austin, TX)

Council on Undergraduate Research (Geoscience Councilor, 2001-present; Chair, CUR-Geosciences Division and Executive Board member, 2006-2008; Member, NCUR Oversight Committee; Facilitator for the CUR Institutes " Beginning a Research Program in the Natural Sciences at a Predominantly Undergraduate Institution", "Institutionalizing Undergraduate Research", and “Proposal Writing Institute”; CUR Consultant and external reviewer, Furman University (2010) and Northern Arizona University (2010)

Committees: Integrated Earth Data Applications portal Policy Committee*:** 2011-present; ***UNAVCO Education/Community Engagement Advisory Committee*,** Member, 2011-present; Chair, 3/13-present; ***COSEE Florida Advisory Committee, 2010-Present

List of Academic Collaborators over Past Five Years:

Expedition 352 Science Team (Drs. Julian Pearce, Mark Reagan, Katerina Petronotis, Sally Morgan, Renat Almeev, Claire Carvallo, Gail Christeson, Eric Ferre, Marguerite Godard, Maria Kirchenbaur, Walter Kurz, Stefan Kutterolf, Hongyan Li, Yibing Li, Katsu Michibayashi, Wendy Nelson, Julie Prytulak, Marie Python, Alistair Robertson, Will Sager, Tetsu Sakuyama, John Shervais, Kenji Shimizu, Scott Whattam)

Dr. Samuele Agostini, CNR-Pisa	Dr. Zachary Atlas, USF
Dr. Allan Feldman, USF	Dr. Fernando Gilbes, UPR-M
Dr. Gladis Kersaint, USF	Dr. Gerhard Meisels, USF
Dr. Dave Mogk, Montana State Univ.	Dr. Frank Muller-Karger, USF
Dr. Michelle Peterson, Univ. Virgin Islands	Dr. Virginia Peterson, Grand Valley State Univ.
Mr. Larry Plank (HCPS)	Dr. Ivan Savov, Leeds Univ.
Dr. Jill Singer, Buffalo State College	Ms. Debbi Stone (Florida Aquarium)
Dr. Sonia Tornarini, CNR-Pisa	Dr. Jim Walker, Northern Illinois Univ.
Prof. Mary Beck, Valencia College	Dr. Richard Treves, Southampton (UK)
Dr. Rosemary Hickey-Vargas, FIU	Dr. James MacDonald, FGCU
Dr. Catherine Chauvel, Univ. Lyon	Dr. Declan DePaor, ODU
Dr. Steve Whitmeyer, James Madison Univ.	Dr. Kristen St. John, James Madison
Dr. Callan Bentley, N. Virginia CC	Dr. Cinzia Cervato, Iowa State Univ.
Dr. John Bailey, Google Inc.	Dr. Paul Karabinos, Williams College
Dr. Terry Pavlis, Univ. Texas El Paso	Dr. Barbara Tewksbury, Hamilton College

Academic Advisors:

Dr. Charles Langmuir, Columbia University
Dr. Julie Morris, National Science Foundation (Postdoctoral)

Recent Advisees: (10 MS; 3 Ph.D.; 48 REU Site Participants)

Dr. Eric Tenthorey (Australian National Univ.); Dr. Livio Tornabene (Univ. Western Ontario); Dr. Ivan Savov (Leeds Univ.), Dr. Jeff Rahl (Washington and Lee Univ.); Dr. William Sullivan (Colby College); Dr. Julie O'Leary (DTM/WHOI); Dr. Meagen Pollock (College of Wooster); Dr. Kyla Simons (Exxon-Mobil); Dr. Marianne Caldwell (HCC), Dr. Cosmin Stremtan (CETAC, Inc.)

JOHN W. SHERVAIS

Professor, Department of Geology, Utah State University, Logan, Utah 84322

john.shervais@usu.edu (435) 797-1274
http://www.usu.edu/geo/shervais/Shervais.html
Google Scholar: http://scholar.google.com/citations?user=E3hyDgsAAAAJ&hl=en

Degrees, Education

Ph.D., 1979, University of California, Santa Barbara
B.Sc., 1971, San José State University, California (Major Geology, Minor Physics)

Dissertation

Petrology and Structure of the Alpine Lherzolite Massif at Balmuccia, Italy
Professor C.A. Hopson, Principal Advisor

Professional Experience

Utah State University, 2000-Present
Professor, Department of Geology
Department Head, July 2000-June 2010

University of South Carolina, 1984-2000
Professor, 1992-2000, *Associate Professor*, 1988–1992, *Assistant Professor*, 1984–1988

Research Associate, University of Tennessee, Knoxville: 1982–1984
Visiting Assistant Professor, University of California, Davis: 1982
Visiting Lecturer, University of California, Santa Barbara: 1981
NATO Post-Doctoral Fellow, Eidgenössische Technische Hochschule (ETH) Zürich, Switzerland: 1980

Awards and Honors

Fellow, Geological Society of America, 1993
NATO Postdoctoral Fellowship, ETH, Zürich, Switzerland, 1979-1980
University of California Regent's Fellow, 1976–1977

Professional Organizations

Geological Society of America (Fellow), The American Geophysical Union, Geochemical Society

PUBLICATIONS – Five Most Relevant

Expedition 352 Scientists, 2015. Izu-Bonin-Mariana fore arc: Testing subduction initiation and ophiolite models by drilling the outer Izu-Bonin-Mariana fore arc. International Ocean Discovery Program Preliminary Report, 352. http://dx.doi.org/10.14379/iodp.pr.352.2015.

Shervais, JW and Jean, MM, 2012, Inside the Subduction Factory: Fluid mobile trace elements in the mantle wedge above a subduction zone, *Geochimica et Cosmochimica Acta*, 95, 270-285.doi:10.1016/j.gca.2012.07.006

Wakabayashi, J and **Shervais, JW,** 2012, Introduction: Initiation and Termination of Subduction: Rock Record, Geodynamic Models, and Modern Plate Boundaries: *Lithosphere*, v. 4, p. 467-468, doi:10.1130/LINT1.1

Shervais, JW, Choi, S-H, 2012, Subduction Initiation along Transform Faults: Initiation of the proto-Franciscan subduction zone. *Lithosphere*, v. 4, p. 484-496, doi:10.1130/L153.1

Shervais, JW, Choi, SH, Sharp, WD, Ross, J, Zoglman-Schuman, MM, and Mukasa, SB, 2011, Serpentinite Matrix Mélange: Implications of Mixed Provenance for Mélange Formation. In Wakabayashi, J and Dilek, Y, eds, *Melanges: Processes of Formation and Societal Significance,* Geological Society of America Special Paper 480, *1-38*. doi:10.1130/2011.2480(01)

PUBLICATIONS – Five Additional

Shervais, JW, Arndt, N., and Goodenough, KM, 2014, Drilling the Solid Earth: Global Geodynamic Cycles and Earth Evolution, *International Journal of Earth Sciences*, DOI: 10.1007/s00531-014-1073-y.

Jean, MM, Hanan, BB, and **Shervais, JW**, 2014, Yellowstone Hotspot – Continental Lithosphere Interaction: *Earth and Planetary Science Letters*, v389, 119-131. doi.org/10.1016/j.epsl.2013.12.012.

Carmody, L, Barry, PH, **Shervais, JW,** Kluesner, JW and Taylor LA, 2013, Oxygen Isotopes in Subducted Oceanic Crust: A New Perspective from Siberian Diamondiferous Eclogites; *Geochemistry, Geophysics, Geosystems*, doi: 10.1002/ggge.20220.

Metcalf, R.V., and **Shervais, J.W.,** 2008, Supra-Subduction Zone (SSZ) Ophiolites: Is There Really An "Ophiolite Conundrum"?, in James E. Wright and John W. Shervais, editors, *Ophiolites, Arcs, and Batholiths: A Tribute to Cliff Hopson:* Geological Society of America Special Paper 438, p. 191–222, doi: 10.1130/2008.2438(07).

Shervais, J.W., 2001, Birth, Death, and Resurrection: The Life Cycle of Suprasubduction Zone Ophiolites, *Geochemistry, Geophysics, Geosystems*, vol. 2, (Paper number 2000GC000080), 20,925 words, 8 figures, 3 tables.

Synergistic Activities:

Shervais was Principal Investigator and Project Director of HOTSPOT: The Snake River Scientific Drilling Project. As PI, Shervais was responsible for financial management of the $7.4M project, funded by DOE ($4.64M), ICDP ($1.1M), a consortium of universities ($850K), and the USAF ($820K). This project is a collaborative effort among ten universities (six U.S, four international) and three Federal agencies (US Geological Survey, Idaho National Laboratory, and the US Air Force).

The goals of Project Hotspot are twofold: first, to document the long-term volcanic and stratigraphic history of the Snake River Plain, its relationship to the Yellowstone-Snake River Plain Hotspot, and to understand how the hotspot has affected the evolution of continental crust and mantle. Our second goal is to evaluate the geothermal potential of southern Idaho. Project Hotspot drilled three deep (1.82 km to 1.94 km) test wells in different geologic settings, and collected more than 5.5 km of core over a period of 18 months.

As Department Head at USU, Shervais developed the PhD program, which has resulted in graduation of a large number of underrepresented minorities in STEM, including an Hispanic male and almost 50% females (Shervais was primary advisor for two of these, the Hispanic male and one female). Shervais was also lead PI on several science education initiatives that included faculty from Geology, Biology, Soils, and Natural Resources (representing four colleges). Shervais is currently Director of the USU Microscopy Facility, which houses a new field emission SEM with EDS, EBSD, and STEM capabilities.

Collaborators:

Barry B. Hanan, San Diego State University
Katherine Goodenough, British Geolological Survey
Jonathan Glen, U.S. Geological Survey
Dennis Nielson, DOSECC Exploration Services
Sung-Hi Choi, Chungnam National University, Korea
Douglas Schmitt, University of Alberta
Lee Liberty, Boise State University
John Wakabayashi, Fresno State Univ.
Nicholas Arndt, Univ. Grenoble
Laura Carmody, University of Tennessee

Graduate and Post-doctoral advisors:

Clifford A. Hopson, Professor Emeritus, UC Santa Barbara, PhD advisor.
Volkmar Trommsdorff, Professor Emeritus, ETH Zürich, Post-doctoral advisor (deceased)
Lawrence A. Taylor, Professor, University of Tennessee, Post-doctoral advisor
Students: 7 PhD, 18 MSc, 11 Undergraduate; Most recent PhD's: Katherine Potter (Anadarko), Marlon Jean (Leibniz Universität Hannover, DE).

2

Katherine A. Kelley
Graduate School of Oceanography, University of Rhode Island, Narragansett Bay Campus
Narragansett, RI 02882 • (401) 874-6838 • kelley@gso.uri.edu

A. Professional Preparation

Education

Macalester College	Geology	B.A., cum laude, 1997
Boston University	Earth Sciences	Ph.D., 2004
Carnegie Institution	Geochemistry	Post-Doctoral Fellowship, 2003-2005

B. Appointments

2011-	Associate Professor of Oceanography, Graduate School of Oceanography, University of Rhode Island
2012-	Research Associate, National Museum of Natural History, Smithsonian Institution
2008-2011	Assistant Professor of Oceanography, Graduate School of Oceanography, University of Rhode Island
2007-	Visiting Investigator, Department of Terrestrial Magnetism, Carnegie Institution of Washington
2005-2008	NSF Advance Assistant Research Professor, Graduate School of Oceanography, University of Rhode Island
2003-2005	Carnegie Fellow, Carnegie Institution of Washington
2000-2001	Presidential University Graduate Fellow, Boston University
1999-2003	National Science Foundation Graduate Research Fellow
1998-1999	Grinnell Fellow, University of Kansas
1997-198	Fulbright Scholar (Philippines)

C. Selected Products

Five most relevant to proposed research

Brounce, M. N., K. A. Kelley, and E. Cottrell, 2014. Variations in $Fe^{3+}/\sum Fe$ of Mariana Arc Basalts and Mantle Wedge fO_2, *J. Pet.*, *55*(12), 2513-2536, doi:10.1093/petrology/egu065.

Kelley, K. A., and E. Cottrell, 2012. The influence of magmatic differentiation on the oxidation state of Fe in a basaltic arc magma, *Earth Planet. Sci. Lett.*, *329-330*, 109-121, doi:10.1016/j.epsl.2012.02.010.

Reagan, M. K., O. Ishizuka, R. J. Stern, K. A. Kelley, Y. Ohara, J. Blichert-Toft, S. H. Bloomer, J. Cash, P. Fryer, B. B. Hanan, R. Hickey-Vargas, T. Ishii, J.-I. Kimura, D. W. Peate, M. C. Rowe, and M. Woods, 2010. Fore-arc basalts and subduction initiation in the IBM system, *Geochem. Geophys. Geosys.*, *11*, Q03X12, doi:10.1029/2009GC002871.

Kelley, K.A., Plank, T., Newman, S., Stolper, E., Grove, T.L., Parman, S., Hauri, E., 2010. Mantle melting as a function of water content beneath the Mariana arc. *J. Pet.* 51, 1711-1738, doi:10.1093/petrology/egq036.

Kelley, K.A., Cottrell, E., 2009. Water and the oxidation state of subduction zone magmas. *Science* 325, 605-607, doi:10.1126/science.1174156.

Five other significant products

Cottrell, E., Kelley, K.A., 2013. Redox Heterogeneity in Mid-Ocean Ridge Basalts as a Function of Mantle Source. *Science* 340, 1314-1317, doi:10.1126/science.1233299.

Cottrell, E., Kelley, K.A., 2011. The oxidation state of Fe in MORB glasses and the oxygen fugacity of the upper mantle. *Earth Planet. Sci. Lett.* 305, 270-282, doi:10.1016/j.epsl.2011.03.014.

Kelley, K.A., Plank, T., Grove, T.L., Stolper, E.M., Newman, S., Hauri, E.H., 2006. Mantle melting as a function of water content beneath back-arc basins. *J. Geophys. Res.* 111, B09208, doi:10.1029/2005JB003732.

Kelley, K.A., Plank, T., Farr, L., Ludden, J.N., Staudigel, H., 2005. Subduction Cycling of U, Th and Pb. *Earth Planet. Sci. Lett.* 234, 369-383, doi:10.1016/j.epsl.2005.03.005.

Kelley, K.A., Plank, T., Ludden, J.N., Staudigel, H., 2003. Composition of altered oceanic crust at ODP Sites 801 and 1149. *Geochem. Geophys. Geosys.* 4, doi:10.1029/2002GC000435.

D. Synergistic Activities

Member of the IEDA User Committee, 2011-present

Member of the NSF-MARGINS/GeoPRISMS Steering and Oversight Committee, 2010-2012

MARGINS distinguished lecturer, 2009-2011

Member of the AGU Fall Meeting Program Committee, 2006-2007

Peer reviewer for NSF, NASA, and NERC proposals and academic journals (Science, Nature Geoscience, Geology, G-cubed, JGR, EPSL, Contributions to Mineralogy and Petrology, Chemical Geology, Journal of Petrology, Journal of Volcanology and Geothermal Research, AGU Monograph)

E. Collaborators and Other Affiliations

Collaborators (Last 48 Months)

Richard Arculus, Australian Natl. Univ.
Mark Behn, WHOI
Elizabeth Cottrell, Smithsonian Inst.
Haiying Gao, Univ. of Mass., Amherst
Jim Gill, Univ. of Calif. at Santa Cruz
Erik Hauri, Carnegie Inst.
Eugene Humphreys, Univ. of Oregon
Matt Jackson, UC Santa Barbara
Charlie Mandeville, USGS
Fernando Martinez, Univ. of Hawaii
Steve Parman, Brown University
Marc Parmentier, Brown Univ.
Mark Reagan, University of Iowa
Nobu Shimizu, WHOI
Robert Stern, University of Texas, Dallas
Yoshi Tatsumi, IFREE-JAMSTEC, Japan
Jessica Warren, Stanford Univ.
Doug Wiens, Washington Univ.

Graduate and Postdoctoral Advisors

Ph.D.: Terry Plank, Boston University (now at LDEO)
Postdoctoral: Erik Hauri, Carnegie Institution of Washington

Current and Former Student Advisees

Zoe Gentes, MS (2015)
Maryjo Brounce, PhD (2014)
Marion Lytle, PhD (2013)

Biographical Sketch

Wendy R. Nelson
Assistant Professor
Towson University

Professional Preparation

Brigham Young University (Provo, UT)	Geology	B.S.	2003
Brigham Young University (Provo, UT)	Geology	M.S.	2006
Pennsylvania State University (State College, PA)	Geosciences	Ph.D.	2009
Carnegie Institution of Washington (Washington, DC)	Geochemistry	Post-doc	2009-2011
University of Houston (Houston, TX)	Petrology & Geochem	Post-doc	2011-2012

Appointments

2015-present	Assistant Professor, Towson University
2013-2015	Co-director of the Geoscience Learning Center, University of Houston
2012-2015	Research Assistant Professor, University of Houston
2011-2012	Postdoctoral Fellow 2, University of Houston
2009-2011	Postdoctoral Fellow, Carnegie Institution of Washington
2007-2009	Graduate Research Assistant, Pennsylvania State University
2005-2006	Geoscience Teaching Assistant, Pennsylvania State University
2005	Adjunct Faculty, Brigham Young University, Idaho

Products

Five Products Related to the Proposed Project

Nelson, W.R., Snow, J.E., Brandon, A.D., Ohara, Y., Isotopic evolution of backarc oceanic mantle. *2014 Goldschmidt Geochemical Conference*, Abstract 4570. INVITED

Furman, T., Nelson, W.R., Elkins-Tanton, L., (in review) Evolution of the East African Rift: Drip Melting, Lithospheric Thinning and Mafic Volcanism. *Geochimica et Cosmochimica Acta.*

Rooney, T.O, Nelson, W.R. Dosso, L., Furman, T., Hanan, B., 2014, The role of continental lithosphere metasomes in the production of HIMU-like magmatism on the northeast African and Arabian plates. *Geology*, 41, 410-422.

Nelson, W.R., Snow, J.E., Brandon, A.D., Ohara, Y., and Lee, C.-T. 2013. Re-Os-PGE constraints on the evolution of backarc oceanic mantle. *Goldschmidt 2013 Geochemical Conference.*

Nelson, W.R., Furman, T., van Keken, P.E., Shirey, S.B., & Hanan, B.B., 2012, Os-Hf isotopic insight into mantle plume dynamics beneath the East African Rift System, *Chemical Geology*, 320-321, 66-79.

Five Additional Significant Products

Nelson, W.R. & Furman, T., 2013, Tag Team Tectonics: mantle upwelling and lithospheric heterogeneity ally to rift continents. *AGU Fall Meeting*, Abstract T13G-01. INVITED

Furman, T., Nelson, W., Elkins-Tanton, L., 2014, Evolution of the East African Rift: Drip melting, lithospheric thinning and mafic volcanism. Abstracts with Programs 46:58.

Nelson, W. R., Dorais, M.J., Christiansen, E.H., and Hart, G.L., 2013, Petrogenesis of Sierra Nevada plutons inferred from Sr, Nd and O isotopes from mafic dikes in Yosemite Valley, CA: *Contributions to Mineralogy and Petrology*

Nelson, W.R., Ionov, D.A., Shirey, S.B., & Prikhod'ko, V.S. 2010, Re-Os-PGE constraints on continental mantle lithosphere assembly: a case study in eastern Russia. *AGU fall meeting*, V13G-02.

Nelson, W.R., Shirey, S.B., 2011, Minerals as mantle fingerprints: Sr-Nd-Hf-Pb in clinopyroxene and He in olivine distinguish and unusual mantle signature beneath the East African Rift System, *Eos Trans. AGU,* Fall Meeting, Suppl., 90, V411H-04

Synergistic Activities

1. Co-organized GeoPrisms East African Rift System mini-workshop *Collaborative Efforts in the East African Rift System* at 2013 AGU fall meeting; Member of the science party aboard R/V Yokosuka YK11-08 (October 2011); Member of the science party for IODP Expedition 352 IBM forearc (Aug-Sept 2014).
2. 2009 Barbara McClintock Fellow – Carnegie Institute of Washington
   2008 Paul D. Krynine Memorial Fund Research Fellowship
   2007-2008 NSF Transforming Earth Systems Science Education Graduate Fellowship
   2007 ConocoPhillips Graduate Student Field Work Fellowship
   2006 Paul D. Krynine Memorial Fund Research Fellowship
3. Invited Speaker: Geoprisms Planning Workship for the East African Rift System (Oct 2012); Invited Abstracts: 2013 AGU Fall Meeting *Continental Rifts and Rifted margins.* 2014 Goldschmidt Geochemical Conference *Peridotites and Mantle Xenoliths in the Continents and Oceans.* 2015 AGU Fall Meeting *Tectonic, magmatic, and geodynamic studies of extensional processes: Applications in Iceland and the Nubia-Somalia-Arabia plate system.*
4. Reviewer: NSF *Petrology and Geochemistry* program and *Tectonics* Program; *Earth and Planetary Science Letters, Lithos, Journal of Volcanology and Geothermal Research, Earth Science Reviews, Neues Jahrbuch für Geologie und Paläontologie*
5. Mentor and lab supervisor to undergraduate Geosciences students investigating trace element abundances in abyssal peridotite and water in nominally anhydrous minerals at UH; Graduate fellow in NSF-funded Transforming Earth System Science Education (TESSE) initiative, active participant in Houston elementary school science awareness projects.

Collaborators & Other Affiliations

Collaborators and Co-Editors (14)

Alan Brandon (University of Houston), Richard Carlson (Carnegie Institution of Washington), Lindy Elkins-Tanton (Arizona State University), Tanya Furman (Pennsylvania State University), David Graham (Oregon State University), Barry Hanan (San Diego State University), Dmitri Ionov (Université Jean Monnet), Biltan Kurkcuoglu (Hacettepe University), Cin-Ty Lee (Rice), Mark Reagan (University of Iowa), Tyrone Rooney (Michigan State University), Jeffrey Ryan (University South Florida), John Shervais (Utah State University), Steven Shirey, (Carnegie Institution of Washington), Peter van Keken (Carnegie Institution of Washington), IODP Expedition 352 Scientists.

Graduate and Postdoctoral Advisors (6)

Eric Christiansen (Brigham Young University), Richard Carlson (Carnegie Institution of Washington), Michael Dorais (Brigham Young University), Tanya Furman (Pennsylvania State University), Steven Shirey, (Carnegie Institution of Washington), Jonathan Snow (University of Houston).

Total Graduate Students Advised (0)

Total Postdoctoral Researchers Sponsored (0)

SUMMARY PROPOSAL BUDGET

YEAR 1

ORGANIZATION **University of South Florida**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed / Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Jeffrey Ryan**				AWARD NO.	

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Jeffrey G Ryan - Professor**	0.00	0.00	0.50	**6,649**	
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.50	**6,649**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**1**) GRADUATE STUDENTS				**6,667**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**13,316**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**1,951**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**15,267**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. U.S. POSSESSIONS)				**0**	
2. INTERNATIONAL				**4,500**	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ **8,000** 2. TRAVEL **0** 3. SUBSISTENCE **0** 4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**2**) TOTAL PARTICIPANT COSTS				**8,000**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**2,800**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**100**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**9,486**	
TOTAL OTHER DIRECT COSTS				**12,386**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**40,153**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **All but Participant Costs and Tuition (Rate: 49.5000, Base: 29566)**					
TOTAL INDIRECT COSTS (F&A)				**14,635**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**54,788**	
K. SMALL BUSINESS FEE				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				**54,788**	

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME **Jeffrey Ryan**	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* **Kelley Schuler**	Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 2

ORGANIZATION **University of South Florida**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed / Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Jeffrey Ryan**				AWARD NO.	

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Jeffrey G Ryan - Professor	0.00	0.00	0.50	6,848	
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.50	6,848	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (1) GRADUATE STUDENTS				6,867	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				13,715	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				1,985	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				15,700	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. U.S. POSSESSIONS)				8,000	
2. INTERNATIONAL				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 1,000 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				1,000	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				750	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				1,000	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				7,786	
TOTAL OTHER DIRECT COSTS				9,536	
H. TOTAL DIRECT COSTS (A THROUGH G)				34,236	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) All but Participants and Tuition (Rate: 49.5000, Base: 30650)					
TOTAL INDIRECT COSTS (F&A)				15,172	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				49,408	
K. SMALL BUSINESS FEE				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				49,408	
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME **Jeffrey Ryan**	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* **Kelley Schuler**	Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

Cumulative

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
University of South Florida

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Jeffrey Ryan

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Jeffrey G Ryan - Professor	0.00	0.00	1.00	13,497	
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	1.00	13,497	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (2) GRADUATE STUDENTS				13,534	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				27,031	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				3,936	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				30,967	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. U.S. POSSESSIONS)				8,000	
2. INTERNATIONAL				4,500	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 8,000 2. TRAVEL 1,000 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (2) TOTAL PARTICIPANT COSTS				9,000	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				3,550	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				1,100	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				17,272	
TOTAL OTHER DIRECT COSTS				21,922	
H. TOTAL DIRECT COSTS (A THROUGH G)				74,389	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				29,807	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				104,196	
K. SMALL BUSINESS FEE				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				104,196	

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Jeffrey Ryan

ORG. REP. NAME*
Kelley Schuler

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

C *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

Budget Justification: University of South Florida

A: Senior Personnel - PI Jeff Ryan requests 0.5 months/year salary to cover his activities in this project (i.e., conducting B isotope work and supervising the work of graduate and undergraduate researchers.)

B: Other Personnel - Two years of summer support is requested for a graduate student, who will primarily be responsible for the proposed Li isotopic studies on Expedition 352 samples.

C: Fringe Benefit rates are 16.94% for faculty, and 0.2%+health insurance ($833 for any single term) for graduate assistants.

E: Travel

1. **Domestic:**
    a. Support for a graduate student and Ryan to conduct Li isotope measurements at the University of Maryland at College Park (estimated duration: two weeks): $2800 (airfare, AirBnB lodging, perdiem)
    b. Support for Ryan to visit Woods Hole Oceanographic Observatory to conduct in situ B-Li isotope measurements using the national ion microprobe facility (two days of machine time): $1000.
    c. Support for Ryan and a graduate student to present results at the AGU Fall Meeting. Registration, airfare, lodging, meals - $1600 each: $3200.
    d. Support for Ryan to attend a GSA Southeastern Section meeting to supervise undergraduate researchers in presenting their results. Registration mileage, lodging, meals: $1000.
2. **International:**
    --Support for Ryan to conduct B isotope measurements at CNR-Pisa, in the labs of Samuele Agostini and Sonia Tonarini (est 2 week visit): $4500 (airfare, AirBnB lodging, perdiem).

F: Participant Support Costs:

--Stipends (at $400/week) for two undergraduate researchers to conduct fluid-mobile element analyses via solution and/or laser ablation ICP-MS, under Ryan's supervision. PI Ryan has had extensive experience in the mentoring of undergraduate researchers in elemental analysis techniques, and providing undergraduates with experiences using both solution and laser-ablation ICP-MS is routine in USF labs.

--$1000 to partially cover travel for undergraduates to present their analytical results at a GSA Southeastern Section meeting. As part of their professional development, Ryan will work with the students to submit and obtain GSA Student Travel Grant funds to partially support their meeting experiences.

G: Other:

1. Funds to cover the expenses of conducting analyses of fluid-mobile trace element abundances via solution and laser-ablation ICP-MS at USF. We estimate some 60 additional laser-ablation and 40 additional solution analysis measurements and beyond those supported by PEA funds.

2. Funds ($1100) to pay for several abstract fees, and to minimally cover publication charges associated with publishing our results in peer-reviewed venues.

6. Other:

--Per-sample charges for 40 Li isotope determinations at the University of Maryland: $2800.

--Per-sample charges for 30 B isotope determinations at CNR-Pisa: $4500.

--Hourly charges for ion probe beam time at WHOI, to be used in determining B and Li isotope ratios on recovered glasses - est. 20-30 analyses depending on abundance levels. $2400.

--Tuition charges for graduate assistant: $431/credit with a summer load of six credits required: $2586 each Summer.

G. Indirect costs at USF are 49.5% of modified total direct costs. Participant costs and tuition are not subject to indirect cost charges.

CURRENT AND PENDING SUPPORT – PI Reagan (UI)

Title: Microbeam analyses of boninite and fore-arc basalt glasses from IODP Expedition 352
Organization/Grant: Consortium for Ocean Leadership
Total Amount: $10,315 **Person-months/year**: 0.5
6/1/2015-1/31/2016 Current

Title: Salary Support for Co-chief Scientist position, IODP Expedition 352
Organization/Grant: Consortium for Ocean Leadership
Total Amount: $113,699 **Person-months/year**: 8.0
7/1/2014-1/31/2016 Current

Title: Collaborative Research: The sedimentary record of continental margin modification through terrane accretion and spreading ridge subduction
Organization/Grant: NSF
Total Amount: $315,717 **Person-months/year**: 1.0
6/1/2016-5/31/2018 Pending

Title: Collaborative Research: Subduction Initiation and development of the nascent Izu-Bonin-Mariana arc: A Petrologic and Geochemical Investigation of IODP Expedition 352 whole rocks and glasses
Organization/Grant: NSF
Total Amount: $100,997 **Person-months/year**: 1.5
6/1/2016-5/31/2018 Pending

Current and Pending Support

(See PAPPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Jeffrey Ryan

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Cruise Participation, IODP Expedition 352

Source of Support: Consortium for Ocean Leadership
Total Award Amount: $ 74,790 Total Award Period Covered: 07/01/14 - 01/31/16
Location of Project: At sea and USF
Person-Months Per Year Committed to the Project. Cal:3.00 Acad: 0.00 Sumr: 0.00

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: COLLABORATIVE: Expanding the Use of Online Remote Electron Microscopy in the Classroom to Transform Undergraduate Geoscience Education

Source of Support: NSF
Total Award Amount: $ 161,648 Total Award Period Covered: 09/01/13 - 08/31/17
Location of Project: USF, FIU, FGCU, and Valencia College
Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 0.75

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Collaborative Research: Google Earth for Onsite and Distance Education (GEODE)

Source of Support: Old Dominion University (subaward on NSF grant)
Total Award Amount: $ 45,116 Total Award Period Covered: 09/01/13 - 08/31/17
Location of Project: USF
Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 0.25

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: COLLABORATIVE: Faculty Development to Support High Impact Activities That Transform Undergraduate Geoscience Education

Source of Support: NSF
Total Award Amount: $ 137,263 Total Award Period Covered: 08/01/11 - 07/31/16
Location of Project: USF, Buffalo State College
Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 1.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Collaborative Research: Subduction Initiation and development of the nascent Izu-Bonin-Mariana arc: Investigation of IODP Expedition 352 whole rocks and glasses

Source of Support: NSF
Total Award Amount: $ 104,196 Total Award Period Covered: 06/15/16 - 06/14/18
Location of Project: USF, Univ. Maryland, Pisa, WHOI
Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Summ: 0.50

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See PAPPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: John Shervais

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Snake River Plain Play Fairway Analysis - Phase 1

Source of Support: U.S. Department of Energy

Total Award Amount: $ 500,000 Total Award Period Covered: 10/01/14 - 10/30/15

Location of Project: UTAH, Idaho

Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 2.00 Sumr: 2.00

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: PEA: Chemo-stratigraphy of the IBM Fore-arc at Sites 1439, 1440, 1441, 1442

Source of Support: Consortium for Ocean Leadership/ US Science Support Program

Total Award Amount: $ 15,000 Total Award Period Covered: 11/01/14 - 01/31/16

Location of Project: Utah

Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 1.00 Sumr: 0.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Collaborative Research: Subduction Initiation and development of the nascent Izu-Bonin-Mariana arc: A Petrologic and Geochemical Investigation of IODP Expedition

Source of Support: NSF - OCE

Total Award Amount: $ 96,271 Total Award Period Covered: 06/01/16 - 05/31/18

Location of Project: Utah

Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 0.50

Support: ☐ Current ☐ Pending ☒ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Snake River Plain Play Fairway Analysis - Phase 2

Source of Support: U.S. Department of Energy

Total Award Amount: $ 1,000,000 Total Award Period Covered: 01/01/16 - 09/30/17

Location of Project: Utah, Idaho

Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 2.00 Sumr: 2.00

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: **Katherine A. Kelley**

Other agencies (including NSF) to which this proposal has been/will be submit- **NSF**

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: **Collaborative Research: The Southeast Mariana Forearc Rift and southernmost Mariana Trough spreading center: New Insights into the Tectonics and Magmatism of Intraoceanic Arcs**

Source of Support: **NSF**

Total Award Amount: **$102,692** Total Award Period Covered: **09/01/10 – 08/31/15**

Location of Project: **University of Rhode Island**

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: **1**

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: **Radiolytic hydrogen and microbial life in subseafloor sediment and basalt (w/ S. D'Hondt and A. Spivack)**

Source of Support: **NASA**

Total Award Amount: **$205,923** Total Award Period Covered: **01/19/12 – 01/18/16**

Location of Project: **University of Rhode Island**

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: **1**

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: **Collaborative Research: 3D Dynamics of Buoyant Diapirs in Subduction Zones (w/ C. Kincaid)**

Source of Support: **NSF**

Total Award Amount: **$145,000** Total Award Period Covered: **08/01/13 – 07/31/16**

Location of Project: **University of Rhode Island**

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: **Collaborative Research: The role of oxygen fugacity in calc-alkaline differentiation and the creation of continental crust at the Aleutian arc**

Source of Support: **NSF**

Total Award Amount: **$234,972** Total Award Period Covered: **08/01/14 – 07/31/17**

Location of Project: **University of Rhode Island**

Person-Months Per Year Committed to the Project. Acad: Sumr: **.5**

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: **Collaborative Research: Upper mantle oxygen fugacity from source to surface**

Source of Support: **NSF**

Total Award Amount: **$55,453** Total Award Period Covered: **08/01/14 – 07/31/17**

Location of Project: **University of Rhode Island**

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: **.5**

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: **Katherine A. Kelley (Page 2)**

Other agencies (including NSF) to which this proposal has been/will be submit-
NSF

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: **GeoPRISMS Post-Doctoral Fellowship: Geochemical constraints on lithospheric conditions beneath the Cascades**

Source of Support: **NSF**

Total Award Amount: **$299,959** Total Award Period Covered: **01/01/16 – 12/31/17**

Location of Project: **University of Rhode Island**

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: **Detecting Recycled Engine Oil Bottoms (REOB) in Existing Asphalt Pavement (w/M.L. Greenfield)**

Source of Support: **Rhode Island Dept. of Transportation (RIDOT) / URITC**

Total Award Amount: **$76,032** Total Award Period Covered: **08/30/15 – 12/31/16**

Location of Project: **University of Rhode Island**

Person-Months Per Year Committed to the Project. Cal: Acad: Sum

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: **Geochemistry and Eruption History of Researcher Ridge: A Test of Conceptual Melt Models at a Slow-spreading Ridge (w/ R.A. Pockalny)**

Source of Support: **NSF**

Total Award Amount: **$552,828** Total Award Period Covered: **08/01/16 – 07/31/19**

Location of Project: **University of Rhode Island**

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: **1/2/2**

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: **Collaborative Research: A multidisciplinary study of mantle plume - subduction Interactions: A case study of the Samoa plume – Tonga arc system (w/ C.R. Kincaid)**

Source of Support: **NSF**

Total Award Amount: **$276,108** Total Award Period Covered: **08/01/16 – 07/31/19**

Location of Project: **University of Rhode Island**

Person-Months Per Year Committed to the Project. Acad: Sumr: **.5**

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: **Collaborative Research: Initiation and development of the nascent Izu-Bonin-Mariana arc: A Petrologic and Geochemical Investigation of IODP Expedition 352 whole rocks and glasses (THIS PROPOSAL)**

Source of Support: **NSF**

Total Award Amount: **$56,993** Total Award Period Covered: **06/01/16 – 05/31/18**

Location of Project: **University of Rhode Island**

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: **1**

*If this project has previously been funded by another agency, please list and furnish information for immediately pre-

Current and Pending Support

(See PAPPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Wendy Nelson

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Collaborative Research: Subduction Initiation and development of the nascent Izu-Bonin-Mariana arc: A Petrologic and Geochemical Investigation of IODP Expedition

Source of Support: NSF

Total Award Amount: $ 46,533 Total Award Period Covered: 06/01/16 - 05/31/18

Location of Project: Towson University

Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 1.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Collaborative Research: Constraining the temporal evolution of mantle plume contributions to magmatism in the Turkana Depression

Source of Support: NSF

Total Award Amount: $ 39,089 Total Award Period Covered: 06/01/16 - 05/31/19

Location of Project: Towson University

Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 0.50

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Collaborative Research: Investigating lithospheric modification and drip beneath East Africa: A coupled lava-xenolith study

Source of Support: NSF

Total Award Amount: $ 154,384 Total Award Period Covered: 01/01/16 - 12/31/17

Location of Project: Towson University

Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 2.00

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Fingerprinting mantle melting in the earliest subduction zone lavas using Re-Os isotopes and PGEs

Source of Support: Consortium for Ocean Leadership

Total Award Amount: $ 42,439 Total Award Period Covered: 07/30/14 - 01/31/16

Location of Project: Towson University

Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 2.00

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

 USE ADDITIONAL SHEETS AS NECESSARY

H. FACILITIES, EQUIPMENT, AND OTHER RESOURCES

Department of Earth & Environmental Sciences, Trowbridge Hall, University of Iowa

Geochemistry labs: The main lab is a 350 sq.ft. metal-free clean laboratory (B40 Trowbridge Hall) that has a positive pressure environment and it is equipped with two laminar flow work stations, two fume hoods, a Millipore ultrapure water system, a separate weighing room with two Sartorius balances (Genius analytical balance and Expert top-loading balance), an Analab closed environment evaporation system, two centrifuges, an ultrasonic bath, several Savillex acid stills, and five temperature-controlled hot plates. This facility was set up to allow dissolution of rock samples in a clean environment to minimise contamination of small samples for ICP-MS trace element analysis and radiogenic isotope analysis. Standard ion-exchange methods are available for separation of Sr-Nd-Pb-Hf and U-Th-Ra for isotopic analysis. Another nearby room (B35B Trowbridge Hall) is used as a general purpose laboratory for chemistry and mineral separations. It has a fume hood, a high-temperature muffle furnace, a drying oven, a large, explosion-proof centrifuge, and a stand-alone laminar flow workbox for chemical separations. A Deltech 1-atm gas mixing furnace allows olivine-hosted melt inclusions to be rehomogenised to glass under controlled redox conditions. There is a dedicated fume-hood for methylene iodide heavy liquid mineral separations. A flux fusion method is set-up to digest rock and soil samples, ready for major element analysis using the ICP-OES instrument (Varian 720-ES) in the Department of Chemistry, just across the street.

Trace Element Analysis Lab: This facility was established in Nov 2009, and it is housed in room B21 Trowbridge Hall. The facility contains the following equipment:

- Thermo X-series II quadrupole ICP-MS, with collision cell (H_2/He mix).
- NewWave 213nm UV laser ablation attached with helium-filled ablation cell.
- Cetac ASX-520 autosampler in a HEPA-filtered enclosure.

UI Electron Microprobe Facility: This facility was established in summer 2014, and it is housed in room 26 in Trowbridge Hall. Day-to-day operations are overseen by a lab manager, and the lab is operated as part of the University of Iowa Central Microscopy Research Facility. The instrument is a JEOL JXA-8230 SuperProbe, equipped with large crystal spectrometers optimised for high sensitivity trace element analysis. Procedures have already been set up for routine analysis of glass, olivine, plagioclase, clinopyroxene, and spinel, as well as high-precision analysis of minor elements in olivine.

UI Scanning Electron Microscope lab: The University of Iowa Central Microscopy Research Facility operates a Hitachi S-3400N variable-pressure, large-chamber, environmental scanning electron microscope (SEM) that is housed in the Department of Earth & Environmental Sciences (room B21H Trowbridge Hall). It is equipped with a Bruker AXS Quantax 400 X-ray microanalysis system for elemental analysis and mapping, and a Gatan ChromaCL color cathodoluminescence detector.

Petrography and image analysis facility: A series of dedicated research microscopes are housed in room B36 Trowbridge Hall: an Olympus BX51 Petrographic microscope + prism for Normarksi imaging, and two Olympus SZX7 stereomicroscopes for mineral picking. An Olympus D70 12.5 megapixel digital camera can be connected to any of these three microscopes. There is also a Nikon CoolScan V slide scanner with adapter for scanning whole petrographic thin sections in ppl and xpl. A MacPro Tower computer with a 30” Cinema HD Display monitor is dedicated to scanning, image analysis, and data processing.

Sample processing facility: A variety of equipment for sample processing (rock crushing and powdering, mineral separation, polishing and mounting), is available in the UI Department of Earth & Environmental Sciences. This includes two Bico jaw crushers, a Bico disc-mill, a Gemini table, two Frantz magnetic separators, a Spex 8000M mixer mill, a Spex shatterbox, disposable sieve screens, heavy liquid separation equipment, a core drill apparatus for removing grains from thin sections and slabs, and a Struers LaboPol 5 polishing machine with dedicated transmitted/reflected microscope for polishing slabs, thin section stubs, and grain mounts and finish work.

Thin-section preparation lab: The UI Department of Earth & Environmental Sciences's rock lab is managed by a full-time technician. It is equipped with diamond saws and specialized grinding equipment for preparing rock thin sections for microscopic and electron microprobe analysis.

Computers: The University of Iowa provides each faculty member with a new computer every three years. Reagan has an iMac desktop, a MacBook Pro, and a MacBook Air. The UI Tectonics/Petrology Laboratory includes 2 dual monitor PC machines with GIS data processing capabilities and several Mac and PC-based machines with image processing and analysis and data reduction capabilities. All offices and laboratories are wired for easy internet access and computer networking configurations, and the whole Earth & Environmental Sciences building also has wireless internet access. Graduate and undergraduate students have access to computer facilities in Trowbridge Hall, including five teaching classrooms with 10-12 networked PC workstations; a computing classroom with 20 PCs and 10 Macs with GIS, GMS, remote sensing, image analysis, and specialized computational software packages, as well as a student computer room with 6 PCs and 2 Macs. The UI Earth & Environmental Sciences Department has an HP color Laserjet Enterprise CP printer and a Lanier LD 370 copier/collator for faculty and staff use
(121 Trowbridge Hall). Other printers and flatbed scanners are available in the labs of the Tectonics / Petrology / Geochemistry faculty group.

Other Resources: Earth & Environmental Sciences has a 25% time electronics / machine-shop technician (shared with Physics & Astronomy) who are available as needed for this project at the University of Iowa. The Civil and Environmental Engineering department and Chemistry department both maintain full-time staff in glassblowing, machine, and electronics shops and operate a comprehensive chemical stockroom. Note, 40% of M. Reagan's appointment at The University of Iowa is for research. Thus, his academic year salary covers one month of effort listed in the Current and Pending statement.

USF Relevant Facilities and Equipment

The Plasma Laboratory at USF maintains a Perkin-Elmer ELAN II DRC quadrupole ICP-MS instrument with a variety of sample introduction systems, including a Cetac LSX 213 Laser Ablation system and a Perkin-Elmer S-200 High Performance Liquid Chromatography system. Additionally the lab maintains a Perkin Elmer Optima 2000DV ICP-optical emission spectrometer, as well as an FTIR spectrometer for volatile analyses, an atomic fluorescence spectrometry for As and other species that can be analyzed via hydride generation; an Ion Chromatography system and powder XRD instruments.

Also available through the USF Stable isotope Laboratory is a gas-source isotope-ratio MS system for O, C, N, H, and S isotopic determinations; and a new Picarro isotopic analyzer system for natural waters.

PI Jeff Ryan has long maintained clean laboratory facilities at USF for boron and fluid-mobile element sample preparation, including extensive sub-boiling distillation systems for the preparation of ultra-pure, B-free water and reagents. As well, USF has general purpose preparation lab spaces, maintained by Dr. Zac Atlas, for standard major and trace element measurements on rocks and natural waters, along with sample crushing and powdering facilities suitable for low-blank, small sample work.

PI Ryan also maintains sectioning, mounting, and sample polishing equipment for use in the preparation of polished thin sections and laser ablation sample mounts. USF is an original core user of the Florida Center for Analytical Electron Microscopy (FCAEM) remotely operable EPMA and SEM instruments, which are routinely utilized by USF Geosciences faculty and students both for research and teaching purposes.

Facilities and Equipment Utah State University

X-Ray Analysis Laboratory [Shervais]

(1) a **Panalytical 2400** wavelength dispersive X-Ray Fluorescence spectrometer with 3.0 KW Rh-anode X-ray tube, a PX-1 multilayer synthetic crystal for light element analysis, plus LiF200, LiF220, PET, GE, and TAP crystals, three X-ray detectors (Ar-flow detector, sealed Xe detector, and scintillation counter), a sample exchange robot, and full sample preparation facilities for pressed powders and glass disks. This instrument is used for whole rock major and trace element analysis on glass beads and pressed powder pellets, using a full suite of USGS and international rock standards.

(2) **Panalytical X'pert Pro** X-Ray Diffraction system, with Cu-tube, automated operation, and complete searchable database of inorganic compounds with automated peak search and identification, using the JSSG inorganic compound database.

(3) Sample preparation facilities, including a fusion lab for making glass disks for major element XRF analysis, a strip furnace for fused bead EMP analysis, Sartorius MC-1 electronic balance, a complete thin section lab, polishing equipment for the preparation of polished probe sections, and clean rock crushing equipment (mini-jaw crusher, ROCKLABS shatterbox).

ICP-MS Laboratory with Laser Ablation [Shervais]

(1) Thermo Scientific X-SERIES 2 ICP-MS (Inductively Coupled Plasma Mass Spectrometer), a high-resolution quadropole mass spectrometer with a discrete dynode electron multiplier detector, with a linear dynamic range of 8 orders of magnitude that measures both pulse counting and analogue signals simultaneously.

(2) New Wave 213 nm laser ablation system with optical and CCD viewing, computer controlled positioning and ablation routines (including pre-ablation sputtering), 4-110 µm spot size, and 1 µm stage resolution. Fully integrated interface with the Thermo X-Series 2 ICP-MS.

Stable Isotope Laboratory [Newell]

The Department of Geology houses a new light stable isotope laboratory that was installed in Fall 2013. The lab includes a Thermo Scientific Delta V Advantage isotope ratio mass spectrometer (IRMS) with standard triple collector and GasBench II with PAL autosampler. The instrument is currently configured to analyze stable isotopes of H and O in water, C of dissolved inorganic carbon in water, and C and O in solid carbonate samples. The lab also houses a Picarro CO_2 Analyzer that can be used to analyze carbon stable isotopes in gas samples. The lab also contains a microbalance and other sample preparation equipment, and the necessary international stable isotope standards for analysis of water, CO_2, and carbonates.

The Stable Isotope Laboratory and the ICP-MS laboratory are both managed and maintained by Andrew Lonero, M.Sc..

Luminescence Geochronology Laboratory [Rittenour]

The USU Luminescence Lab is equipped with two automated TL/OSL dating systems (Model Risø TL/OSL-DA-20A/B), the latest generation luminescence reader, with a laser-driven single-grain attachment that allows for the dating of individual sand grains. The lab has all the facilities needed for OSL analysis including a dedicated sample preparation lab under constant amber safe-light conditions, which includes a HF-certified fume hood, centrifuge, drying oven, de-ionized water system, full set of sieves, and the required acids and heavy liquids for sample processing. The outer lab (in the light) houses a new PC workstation with the OSL analysis software provided by Risø National Labs. The USU Luminescence lab is also equipped with a field portable gamma spectrometer for in-situ dose-rate measurements and an AMS hand auger system for core sample collection. The Department of Geology has a Giddings Probe and equipment that can also be used for coring.

Microscopy Core Facility [Director: John Shervais, Professor; Manager: FenAnn Shen, PhD]

The Microscopy Core Facility at Utah State University is a research service unit managed by the Office of Research and Graduate Studies. The facility maintains a scanning electron microscope equipped with EDS and EBSD, and a laser dissection microscope. The facility provides microscopy service, project consultation, and user training for scanning electron microscopy and laser dissection microscopy.

FEI Quanta FEG 650: This field-emission scanning electron microscope has multiple capabilities. Besides the traditional high vacuum mode to image and analyze conductive and non-conductive material, the FEI Quanta FEG 650 has a low vacuum mode to image dry insulators and an environmental mode to image wet (biological) samples without chemical fixation. It is also equipped with a STEM detector that can image the bulk structure of electron transparent materials with a maximum electron energy of 30 KeV, and with a heating/cooling stage. Remote control software provide SEM access to classroom demonstration and research in regional campuses.

Oxford EDS with X-Max detector and EBSD with NordlysMax detector: Analytical instruments attached to the SEM include an Oxford energy dispersive X-ray spectrometer (EDS) for chemical analyses and an electron backscatter diffractometer (EBSD) for crystal structure information including crystal orientation and grain size distribution.

EMS-150 ES carbon/metal coater: EMS-150 ES is a high vacuum coating system with an interchangeable inserts for metal sputter coating or carbon evaporation. Au/Pd sputter coats provide a conductive thin film to inhibit surface charging, reduce thermal damage and enhance secondary electron emission in scanning electron microscopy. Carbon coats are used to inhibit surface charging during energy dispersive X-ray analysis.

Facilities, Equipment, and Other Resources • GSO/URI

Laboratory Facilities:

Micro-Analytical Geochemistry Facility

• Solution-based ICP-MS

The geochemistry laboratory at the Graduate School of Oceanography (GSO), University of Rhode Island houses a Thermo Electron X-series 2 Quadrupole ICP-MS equipped with a SIM electron multiplier that operates in pulse counting and analog modes, and has interchangeable Xs and Xt interfaces. It has Plasma Screen and Collision Cell Technology options that allow for optimizing the signal/background ratio and reducing polyatomic interferences. Sample introduction methods for dissolved rock samples include a fully automated ESI auto-sampling system, a peristaltic pump and Peltier cooled spray chamber with a concentric nebulizer, and a desolvating nebulizer and a hydride generator for specialized sample introduction. The sensitivity of the Thermo instrument allows for single figure ppt to ppq detection in solution mode across the mass range, including Li, Be, and U and up to 10 ppm of major elements. This lab performs routine analyses of 38 minor and trace elements (Li, Be, Sc, Ti, V, Cr, Co, Ni, Cu, Zn, Ga, Rb, Sr, Y, Zr, Nb, Cs, Ba, Ba, REE, Hf, Ta, Pb, Th, U) and protocols may be optimized for several others (e.g., K, As, Sb). Since the summer of 2005, the GSO laboratory has been routinely used for analyses of igneous rocks. Typical sensitivities for a 1 ppb solution are 60,000 cps @ ^{7}Li to 400,000 cps @ ^{238}U. Analyses of volcanic rocks have average reproducibility of <2% RSD across the mass range.

• Laser ablation ICP-MS

Laser ablation ICP-MS analyses of volcanic glasses, melt inclusions, magmatic phenocrysts, and experimental run products will be performed at GSO by Katherine Kelley and the GSO graduate student. The ICP-MS lab is equipped with a New Wave UP213 nm Nd-YAG laser that is connected to the Thermo Electron X-series 2 ICP-MS. Detection limits in glasses are typically in low ppm to ppb range depending on ablation and instrument conditions. Typical uncertainties are ≤5% relative. The lab performs routine laser ablation analyses of >40 major, minor, and trace elements (Li, Be, Mg, P, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Rb, Sr, Y, Zr, Nb, Cs, Ba, Ba, REE, Hf, Ta, W, Pb, Th, U) *in situ* using spots as small as 20 µm. The following glass standards are available for LA ICP-MS calibration: USGS basaltic reference glasses (BHVO-2G, BCR-2G, BIR-1G); MPI-DING glasses (ATHO-G rhyolite, T1-G quartz diorite, StHS6/80-G andesite, KL2-G basalt, ML3B-G basalt, GOR128-G komatiite and GOR132-G komatiite); NIST synthetic glasses (NIST 610, 612, 614, and 616).

• Micro-FTIR Spectroscopy

In summer 2013, Kelley's labroatory welcomed the addition of a Thermo Nicolet iS50 Fourier transform infrared spectrometer with Continuum microscope interface, for micro-analysis of dissolved volatiles (H_2O, CO_2, OH^-, CO_3^{2-}) in glasses. The system is equipped with a micro-ATR crystal for attenuated total reflectance measurements, and a fully automated sample stage for fine-scale sample mapping. The system includes a self-contained purge gas generator for purging the sample area with dry, CO_2-free air. The Continuum microscope has a 15x reflachromat objective and condenser, and 250 µm and 50µm MCT-A detectors for high-resolution data collection at small spot sizes over a broad spectral range. Kelley also works with data reduction routines developed by Sally Newman (Caltech) for the removal of spectral backgrounds for the precise determination of CO_3^{2-} peaks.

Clean Chemistry Laboratories

Chemical preparations of bulk rock samples are performed at the associated clean chemistry lab facility under the direction of Dr. Katherine Kelley. The clean laboratory includes an 18.2 MΩ Milli-Q water polisher, a class 100 polypropylene laminar flow fume hood, and two Savillex DST-1000 teflon stills, and two quartz stills for the in-house production of triple-distilled acids used throughout sample preparation. High-precision balances and Teflon digestion vials are used to weigh out and dissolve sample powders using HF-HNO_3 acid attack at low temperatures (≤100°C). Using HF-HNO_3 digestions, no sample instability problems occur. The lab is also equipped with a broad range of international and in-house igneous and sedimentary rock standards spanning the compositional range of basalt to rhyolite, including those from USGS and GSJ.

In addition, Kelley also maintains a semi-clean laboratory for the preparation of whole-rock samples for major element analysis. This laboratory hosts two 1200°C muffle furnaces and associated safety equipment, a high precision balance, ultra-high purity graphite crucibles, and other associated consumables for dissolving rocks *via* Li-metaborate flux fusion.

Microscopy and Sample Preparation Laboratories

Several stereo binocular microscopes (Nikon SMZ-800) and petrographic microscopes with reflected/transmitted light capability (Reichert and Zeiss) and digital camera attachments are openly available for this project, and are routinely used in sample picking, polishing, and description/documentation.

Facilities for bulk rock sample preparation include: large- and small-radius diamond blade rock saws, a small-volume, alumina-plate jaw crusher for reducing scoria and rock samples to workable sizes; a Spex 8000M Mixer/Mill with high-purity alumina vessel for reducing crushed samples to powder for whole-rock analysis; plastic, stainless, and brass sieves for separating crushed samples into size fractions; immersion, picking, and mounting media for glass and melt inclusion wafer preparation; a stationary 4-grit polishing table and an 8” mechanical lapping wheel with interchangeable plates for efficient, high-quality sample grinding and polishing.

Computer Facilities

Computing facilities available for this work include the GSO Computer Center, which houses a variety of Mac and PC-based workstations available to the GSO community. Kelley also has two computers available for the project, including a MacBook Pro laptop which is Kelley’s primary work computer, and an iMac CoreDuo desktop computer available to project personnel in a group laboratory. The iMac is used primarily for image processing, poster preparation, and off-line reduction of ICP-MS and FTIR data.

Other Facilities and Major Equipment:

Beamline 13-ID-E at the Advanced Photon Source, Argonne National Laboratory

The PIs will make extensive and efficient use of projected beam time allocations at beamline 13-ID-E, a new beamline at Sector 13 of the APS. Kelley has had success in securing time through General User Proposals at APS. The new x-ray microprobe beamline at Sector 13 is equipped with two Si channel-cut monochromators, one with a (111) lattice cut and one with a (311) lattice cut. The monochromator configuration includes a liquid nitrogen cooling system, and a photon shutter to maintain beam on the crystal when hutch safety shutters are engaged, to minimize thermal drift. Incident beam and detector geometry are configured with samples sitting at a 45° angle between the incident beam and the detector. The detector configuration includes a Vortex ME4 silicon drift diode array. The storage ring at APS operates at 7 GeV. The anticipated photon flux at station 13-ID-E will depend on the energy being monitored, but at ~10 keV the expected photon flux is ~1011 photons/second at beam sizes of ~1μm to 500 nm.

FACILITIES, EQUIPMENT AND OTHER RESOURCES

Towson University

The NSF-funded Urban Environmental Biogeochemistry Laboratory (UEBL) is a college-level analytical facility within the Fisher College of Science and Mathematics at Towson University (TU). The UEBL is supported by both external and internal funds. It houses an inductively coupled plasma mass spectrometer (ICP-MS) and an ICP-Time of Flight-MS with Laser Ablation capabilities that are equipped to conduct trace metal and isotopic analysis of water, tissue and soil samples. Also available in the UEBL are an X-ray Fluorescence Spectrometer, 2 ion chromatographs for cation/anion analyses, a carbon-nitrogen analyzer, and an elemental analyzer (C, H, N, O, and S). An X-ray diffractometer is available to the members of the Fisher College of Science and Mathematics at TU.

The preparation of samples for these instruments is conducted in a fully equipped sample preparation facility (drying oven, electronic balance and grinding mill with agate ball and container set), sieves for grain size analysis, and a supporting clean laboratory room for all wet chemistry. The clean laboratory was built with NSF funding and completed in 2012. It is rated at class 10,000 throughout the room and class 1000 within the laminar hood spaces. All of these facilities are freely available for use by the PI, geoscience faculty, and other UEBL-trained personnel. In addition, facilities for organism exposure experiments including a greenhouse and a set of temperature and humidity controlled incubators are available for use by the PI and other UEBL trained personnel.

The Fisher College of Science and Mathematics at Towson University provides research support through three key staff that are employed at the College level and therefore available to faculty in all departments. An instrument specialist, who has a masters in geochemistry and has been on staff within the UEBL since 2006, has broad instrumental experience and has worked extensively with undergraduates in teaching laboratory and research settings. The College also supports a fully equipped electronics shop, which is staffed by a full time technician with a degree in electrical engineering from Johns Hopkins University. A fully equipped machine shop is also located in Smith Hall and is staffed with a full-time employee dedicated to working with faculty and students.

Instrument: Thermo PQ ExCell Inductively Coupled Plasma Mass Spectrometer (ICP-MS)
In service since: 2001
Sample Media: geological materials, plant and animal tissues, aqueous samples
Capabilities: Determine trace element concentrations in dissolved samples or aqueous solutions. high ppt to wt% levels.

Instrument: Bruker AXS S4 Explorer X-ray Fluorescence Spectrometer (XRF)
In service since: 2005
Sample Media: geological materials, plant and animal tissues, aqueous samples
Capabilities: Determine concentrations for elements Be-U in glass disks, pressed pellets, powders or aqueous solutions. ppm to wt% levels.

In addition to our laboratory analytical capabilities, we can support field investigations with sample collection expertise and equipment for surface soils, surface waters and ecological sampling.

<u>Carnegie Institution of Washington</u>

The Geochemistry/Cosmochemistry group at the Department of Terrestrial Magnetism has the following facilities available to the PIs for this project:

1) Clean laboratories and sample preparation space. DTM has over 4,000 square feet of clean laboratory space separated into 14 rooms. Mary Horan, the full-time geochemical laboratory manager, oversees clean lab activity, including coordinating procedure and masterfully training new users. In addition to laboratory space, DTM also has a rock room (equipped with rock saws, ceramic jaw crusher, disc mill apparatus, alumina shatterbox equipment) and mineral separation facilities (stereomicroscopes, magnetic separators, and heavy liquids).

2) Thermo Scientific Triton TIMS (installed in 2004) contains nine movable faraday cups and one single ion multiplier. The instrument is known for its high sensitivity and accuracy. When operated in positive mode (PTIMS), it can measure lithophile isotopes of interest in this study (Sr and Nd). Switching to negative mode (NTIMS) allows for Os analysis. Here, the ion multiplier is crucial for measuring ultra-low concentration Os in low abundance samples.

3) Nu Plasma HR ICP-MS (installed in 2009) has 12 faradays and 4 multipliers. It is ideally suited to measure isotope dilution concentration of of Rb, Sm, Lu, Hf, Pb, Re, and PGEs separated during column chromatography. Tim Mock is the full time instrument technician and oversees the smooth operation of both the TIMS and the ICP-MS.

4) Thermo iCAP Q ICP-MS (installed in 2012) is a quadrupole ICP-MS redesigned to minimize bench-space footprint. It is equipped with a collision cell in order to minimize mass interferences.

INTEGRATED EARTH DATA APPLICATIONS iedadata.org

Data Management Plan

Primary Investigator: Mark Reagan
Institution: University of Iowa
Project: Collaborative Research: Initiation and development of the nascent Izu-Bonin-Mariana arc: A Petrologic and Geochemical Investigation of IODP Expedition 352 whole rocks and glasses
Co-PIs: John Shervais, Jeffrey Ryan, Katherine Kelley, Wendy Nelson
NSF Division: OCE **Solicitation Info:** Marine Geology and Geophysics **Submission Date:** 08/15/2015

Overview: We will determine major element, trace element, and isotopic compositions of glasses and whole rocks collected during IODP Expedition 352 using a variety of techniques. Fe speciation data for volcanic glasses also will be collected.

Data description: We will collect a geochemical data on samples taken from drill cores during IODP Expedition 352 to the Bonin forearc. Data types will include:
glasses - major element concentrations (EMP), trace element concentrations - (LA-ICPMS), volatile element concentrations (FTIR), O isotopes (laser fluorination) B and Li isotopes (SIMS); Fe speciation (XANES);
whole rocks - major element data (XRF), trace element concentrations (ICPMS), Os isotopes (TIMS), PGE element and Re concentrations (ICPMS), B isotopes (TIMS), Li isotopes (MC-ICPMS)
pyroxenes - OH concentrations by SIMS.

Description of existing data and samples: The samples to be analyzed were collected during IODP Expedition 352 by expedition scientists.

Data analysis summary: EMP analyses of glasses for major elements (~65, including data collected with PEA funds)
LA-ICPMS analyses of glasses for standard trace elements (~65)
LA-ICPMS analyses of glasses for fluid-mobile elements (~50)
FTIR analyses of glasses for H2O, OH, and CO2 concentrations (~20)
Laser fluorination analyses of glasses for O isotopes (~20)
SIMS analyses of glasses for B & Li isotopes (~20)
XANES analyses of glasses to determine Fe speciation (~65)
SHRIMP-SI analyses of pyroxenes for OH abundances (8-10 samples, 10-20 px per sample)
XRF analyses of whole rocks for major element compositions (130-150)
ICPMS analyses of whole rocks for standard trace element concentrations (130-150)
TIMS analyses of whole rocks for Os isotopic compositions (65)
ICPMS analyses of whole rocks for PGE element abundances (65)
ICPMS analyses of whole rocks for fluid mobile trace element concentrations (~500)
MC-ICPMS analyses of whole rocks for Li isotopes (~20)
TIMS analyses of whole rocks for B isotopes (~20)

Includes field work? No

Expected data product #1
Data type: Analytical

Responsible investigator: Mark Reagan
Product description: Major end trace element abundances in glasses
O isotopes in glasses
Volatile concentrations in glasses
Intended repository: PetDB
Timeline for data release: Two Years from acquisition/analysis

Expected data product #2
Data type: Analytical
Responsible investigator: John Shervais
Product description: Major and trace element compositions of whole rocks
Intended repository: PetDB
Timeline for data release: Two Years from acquisition/analysis

Expected data product #3
Data type: Analytical
Responsible investigator: Jeffrey Ryan
Product description: Fluid-mobile trace element compositions of glasses and whole rocks
B & Li isotopes in glasses and whole rocks
Intended repository: PetDB
Timeline for data release: Two Years from acquisition/analysis

Expected data product #4
Data type: Analytical
Responsible investigator: Wendy Nelson
Product description: Os isotopes in whole rocks and glasses
PGE element abundances in whole rocks and glasses
Intended repository: PetDB
Timeline for data release: Two Years from acquisition/analysis

Expected data product #5
Data type: Analytical
Responsible investigator: Mark Reagan
Product description: OH concentrations in pyroxenes
Intended repository: PetDB
Timeline for data release: Two Years from acquisition/analysis

Expected data product #6
Data type: Analytical
Responsible investigator: Katherine Kelley
Product description: Fe speciation in glasses
Intended repository: PetDB
Timeline for data release: Two Years from acquisition/analysis

Maryjo Brounce
1200 E. California Blvd.
MC 170-25
Pasadena, CA 91125
(626) 395-6409

6 August, 2015

Mark Reagan
Department of Earth & Environmental Sciences
University of Iowa
Iowa City, Iowa 52242

Dear Mark,

I am writing to confirm my support for your project to investigate the chemical composition of crust formed as the result of the onset of subduction in the Izu-Bonin-Mariana subduction system. The samples returned from IODP Expedition 352 will inform our understanding of subduction initiation and the mechanisms by which materials recycle during subduction, a critical aspect of plate tectonics and a contributing factor in forming and maintaining a habitable surface environment.

Specifically, I acknowledge my partcipation in *Task 1.2*, to analyze and assess the water and CO_2 contents and oxygen isotopic ratios of submarine glasses from IODP Expedition 352 and other samples related to the initiation of subduction along the Izu-Bonin-Mariana margin. I have six years experience with fourier transform infrared (FTIR) spectroscopic measurements of H and C species in natural, terrestrial glasses. I have the full permission and encouragement of George Rossman to analyze samples for this project in the Mineral Spectroscopy Laboratory at the California Institute of Technology. I am also experienced in making laser fluorination measurements of oxygen isotope ratios in natural, terrestrial glasses and have the full permission and encouragement of John Eiler to analyze samples for this project in the Isotope Mass Spectrometry Laboratory at the California Institute of Technology. The total estimated cost of both FTIR and laser fluorination analyses on 8-10 samples is $1,125.

I wish you the best of luck and look forward to working together.

Sincerely,

Maryjo Brounce

Maryjo Brounce
Postdoctoral Scholar

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MACQUARIE University

Prof. Mark Reagan
College of Liberal Arts and Sciences
Department of Earth and Environmental Sciences
121 Trowbridge Hall
Iowa 52242-1379

7 February 2015

Dear Mark,

Re: $^{16}O^{1}H^{-}$ concentrations in pyroxenes

I would like to confirm my enthusiasm for collaborating with you on your investigation of the **Subduction Initiation and development of the nascent Izu-Bonin-Mariana arc**. Subduction related processes related to the formation of island arcs are poorly understood, even though the formation of island arcs is important for continued evolution of the continental crust. It can be demonstrated that the water (and by inference other 'volatile' gases such as CO_2) plays an important role in the production of magmas at incipient island arcs, however, currently very limited quantitative data exists.

To better constrain the water contents in volcanic rocks, I have recently carried on developing and testing a method (originally suggested by Wade et al. (2008)) for quantifying magma water contents through the direct analysis of water (HO^-) in trace amounts within the common magmatic mineral pyroxene. Pyroxenes are separated and polished using rock processing equipment at Macquarie University, including the high-voltage rock disintegration tool (Selfrag). They are then removed from the polishing medium and remounted in indium before analysis on the relatively new ion-probe (the Sensitive High Ion MicroProbe – Stable Isotopes – housed at the Australian National University – please see Turner et al. 2015). Using new pyroxene-melt partitioning data for water (Adam et al. 2015), direct analysis of water within the pyroxenes can be used to estimate the water content of the melt. In many rocks this will be the only way to estimate the water contents of the pre-erupted magmas and therefore although relatively expensive per sample ($AUD 9,450 for 8 samples – and this is mainly due to the cost of the ionprobe time), I feel the project will benefit considerably from these analyses.

I wish you the very best of luck on your proposal and look forward to working with you in the near future.

Yours sincerely,

Dr Michael Turner

CARNEGIE
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SCIENCE

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Dr. Wendy R. Nelson
Assistant Professor
Dept. of Physics, Astronomy, and Geosciences
Towson University
426-F Smith Hall
Towson, MD 21252

July 22, 2015

Dear Wendy,

Matt Scott, the President of the Carnegie Institution for Science, has approved my request for your continued appointment as a DTM Visiting Investigator through the end of 2016. While this appointment carries no salary, it bestows full access to DTM facilities and allows you to pursue your collaborations at DTM. We look forward to continued visits to our campus particularly now that you will soon be moving back to the mid-Atlantic.

Cheers,
Rick

Richard W. Carlson
Director
Department of Terrestrial Magnetism
Carnegie Institution of Washington

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August 11, 2015

Prof. Jeff Ryan
School of Geosciences
University of South Florida
4202 East Folwer Ave., NES 201
Tampa, FL 33620-5201

Dear Jeff,

We would be happy to have you (and your student) visit our lab to carry out lithium isotope analyses of boninites and basalts from IODP expedition 352. You are familiar with our chemical and mass spectrometry procedures, which should expedite the analyses. Our long-term precision is around 1 ‰ (based on multiple analyses of our in-house pure Li solution, UMD-1), but often proves to be better than this within a given suite of samples based on repeat analyses of rock samples (operator dependent).

Either myself, Sarah Penniston-Dorland or Bill McDonough will be available to assist you if the need arises, in addition to Richard Ash who runs the plasma lab. Please budget for $70/analysis, which will cover the costs of rock dissolution, chemical separation and mass spectrometry.

Good luck with your proposal!

Sincerely,

Roberta L. Rudnick

Roberta L. Rudnick
Distinguished University Professor

WOODS HOLE OCEANOGRAPHIC INSTITUTION

Dr. Horst R. Marschall, *Associate Scientist, Geology and Geophysics*

Prof. Jeffrey G. Ryan, Ph.D.
School of Geosciences
University of South Florida
4202 East Fowler Ave., NES 201
Tampa, FL 33620-5201

Woods Hole, August 11, 2015

Dear Jeff,

Thank you for contacting me about your research proposal on the genesis of boninites and fore-arc tholeiites from the Izu-Bonin arc system. This project is very interesting to me and the IBM is a great place to test some of the recent ideas on slab dehydration. Specifically, processes that happen in and above the subducting slab in the shallower part of subduction zones between the trench and the arc can be uniquely addressed with your sample set. Isotopes of the light elements lithium and boron are ideally suited to track fluid release from sediments and altered oceanic crust. This connects well with my own research interests in the isotope geochemistry of these elements in the crust and mantle.

The ion-microprobe lab at WHOI is operated as an NSF-supported national facility, the "Northeast Ion-Microprobe Facility" (NENIMF) and hosts a large number of external users every year. Access is open to researchers from the US and other countries and is charged on the base of fixed hourly rates that are accepted by the NSF. The academic user fee is $120 per hour for the Cameca imf1280 for NSF-funded projects. The NENIMF SIMS lab and associated facilities at the Woods Hole Oceanic Institution are capable of the sample preparation and analyses that you propose. I will be pleased to assist you during your visits to NENIMF and WHOI to ensure that the highest quality data will be generated. I would also be looking forward to collaborative research, for example in the fields of subduction-zone trace-element transport and magma generation.

For B and Li isotopes I estimate you could complete approximately 15–20 analyses in a 12-hour day (+standards) for the low concentration samples ($0.5 - 2.5\,\mu g/g$). For samples with higher concentrations you could run faster analyses without restricting analytical precision, and therefore run more analyses in a given time. We recently enhanced our capabilities in analyzing B isotope ratios at very low concentrations and provide this technique to external users. At B concentrations $> 2.5\,\mu g/g$, we routinely get $1.0 - 1.5$ ‰ precision (2RSE) for a single spot analysis, and you can expect that that will be sufficient to readily distinguish unmodified mantle from anything that was affected by subduction-related fluids. We also routinely perform lithium isotope analyses in mineral grains (Cpx, etc) and glasses. A number of glass standards are available in our lab (e.g., MPI-DING) for which boron and lithium isotope values have been determined and are published. Lithium is more sensitive than B in SIMS, so that basaltic glasses with $8\,\mu g/g$ Li are expected to produce analysis with sub-permil precision.

Woods Hole Oceanographic Institution

Dr. Horst R. Marschall, *Associate Scientist, Geology and Geophysics*

I wish you all the best for your proposal and hope to see you soon at WHOI. Please do not hesitate to contact me again in case any further information or clarification is needed.

with the best regards,

Dr. Horst R. Marschall

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Pisa (Italy) August 12th, 2015

To whom it may concern:

Subject: official declaration

I declare my interest to cooperate with prof. Jeffrey G. Ryan of University of South Florida. I found his project on the initiation of subduction zones very ground-breaking and really very interesting, thus I will be very glad to help him with B isotopic measurements on samples carried during IODP cruises.

Clean rooms, TIMS labs and other IGG facilities are fully available to carry out analytical data. I will be pleased to host here Prof. J.G. Ryan, and/or anyone of his students or collaborators, to train him during all the steps of sample preparation and B purification, sample loading and measurements, in the frame of the proposed work plan.

Because my institution provides no ordinary funds for laboratory managing, I only ask a contribution to cover the analytic costs, which is about 150 EUR per sample.

Sincerely Yours,

Samuele Agostini
(IGG-CNR Researcher
Responsible of Clean Rooms-TIMS Labs)

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