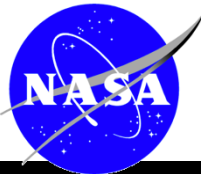


MoonDB



A DATA SYSTEM FOR ANALYTICAL DATA OF LUNAR SAMPLES

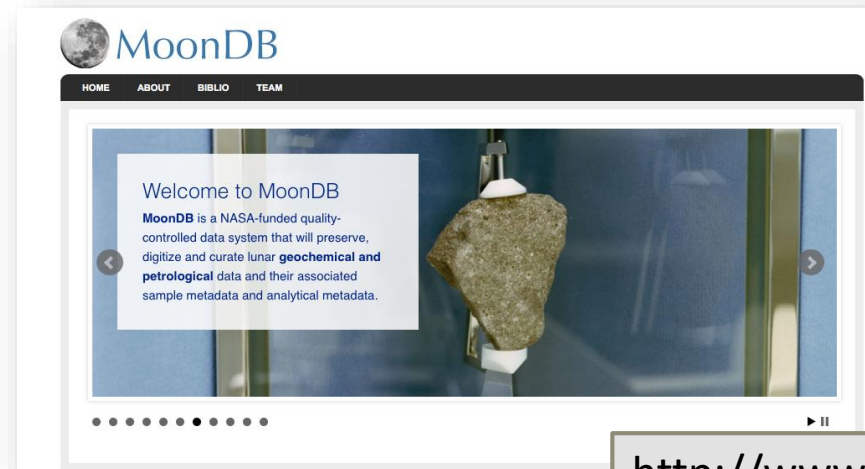


Funded by the NASA PDART Program

Kerstin Lehnert
Peng Ji

Lamont-Doherty Earth Observatory, Columbia University

CONTENT



<http://www.moondb.org>

- OVERVIEW OF THE MOONDB PROJECT
- MOONDB SYSTEM ARCHITECTURE
 - DATA MODEL
 - USER INTERFACE FOR SEARCH & DATA RETRIEVAL
 - MACHINE-ACTIONABLE INTERFACES (APIs)
- MOONDB DATA CURATION
- OUTLOOK: MOONDB PHASE 2

PROJECT OVERVIEW



PROJECT PARTICIPANTS

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CLIVE NEAL
MARC NORMAN
CHARLES SHEARER
LAWRENCE TAYLOR
JEFFREY TAYLOR
PAUL WARREN

PROJECT TIMELINE

- **DEVELOPMENT PHASE 2015 – 2017**
 - DEVELOPMENT OF DATABASE & TOOLS FOR DATA
 - COMPILATION OF HISTORIC & RECENT GEOCHEMICAL DATA
 - DATA RESCUE
- **MOONDB PHASE 2: 2018 – 2020**
 - COMPLETION OF DATA SYNTHESIS, INCLUDE LUNAR METEORITES AND GEOCHRONOLOGY

MOONDB GOALS

- MAXIMIZE THE SCIENTIFIC IMPACT OF PAST, PRESENT, & FUTURE LUNAR SAMPLE STUDIES
- MINIMIZE DUPLICATE ANALYSES OF LUNAR SAMPLES TO ENSURE LONG-TERM HEALTH OF THE APOLLO SAMPLE SUITE
- FACILITATE INTEGRATION OF LUNAR SAMPLE DATA WITH PLANETARY DATA INFRASTRUCTURES



- **REQUIREMENTS:**

- PROVIDE A SYSTEM THAT MAKES LUNAR SAMPLE ANALYTICAL DATA **FAIR**
- SYNTHESIZE & HARMONIZE DATA FROM THE LITERATURE FOR ADVANCED DATA MINING.
- PROVIDE A PLATFORM FOR FUTURE DATA TO BE SHARED AND INTEGRATED WITH THE HISTORICAL DATA
- “RESCUE” UNPUBLISHED DATA



MOONDB PROJECT COMPONENTS



- LAMONT GEOINFORMATICS RESEARCH GROUP:
 - DEVELOP & OPERATE THE MOONDB DATABASE AND USER INTERFACE
 - COMPILE & INGEST LEGACY DATA FROM THE LITERATURE
 - ASSIST INVESTIGATORS WITH CONTRIBUTING UNPUBLISHED DATA
- JOHNSON SPACE CENTER:
 - FACILITATE INVOLVEMENT OF MEMBERS OF THE LUNAR SAMPLE COMMUNITY IN RESCUING AT-RISK DATA
 - PROVIDE GUIDANCE AND TECHNICAL ADVICE FOR DATA COMPILATION
 - LINK JSC DATABASES WITH MOONDB, IMPLEMENT IGSN (PID FOR SAMPLES)

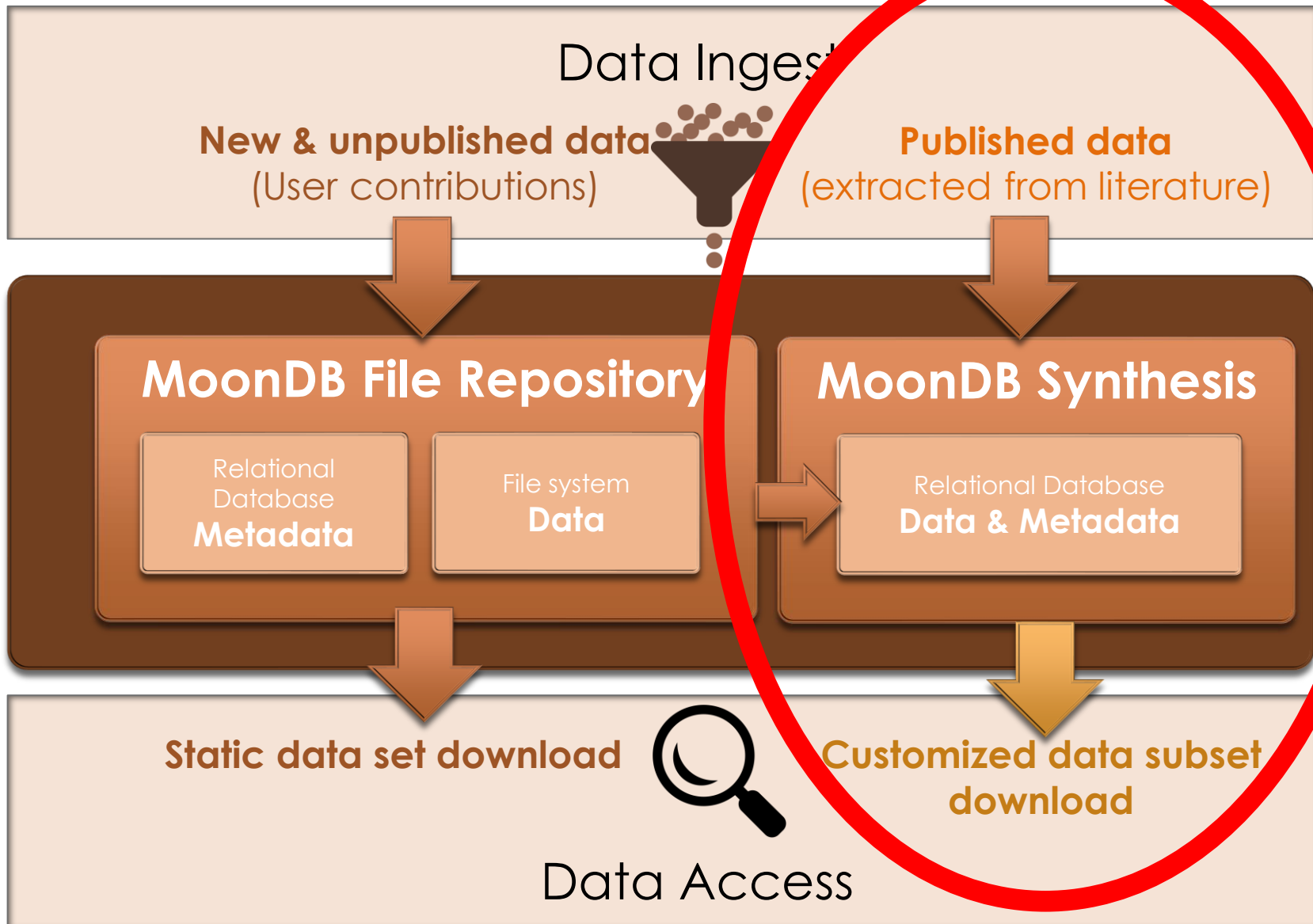
BUILDING ON EXISTING CAPABILITIES



- DATA PRESERVATION & PUBLICATION: **EARTHCHEM LIBRARY**
 - DATA BEST PRACTICES: PROVENANCE METADATA, SAMPLE PIDS (IGSN)
 - FOCUS ON GEOCHEMICAL, PETROLOGICAL, & GEOCHRONOLOGICAL DATA
 - DOI REGISTRATION (DATACITE PUBLICATION AGENT)
- DATA SYNTHESIS: **PETDB, EARTHCHEM PORTAL**
 - DATA MODEL, CURATION WORKFLOWS, UI DESIGN
- PERSISTENT UNIQUE IDENTIFICATION OF MATERIAL SAMPLES: **IGSN, SESAR**
 - SAMPLE REGISTRY WITH METADATA CATALOG & REGISTRATION TOOLS
 - INTERNATIONAL GOVERNANCE OF IGSN SYSTEM



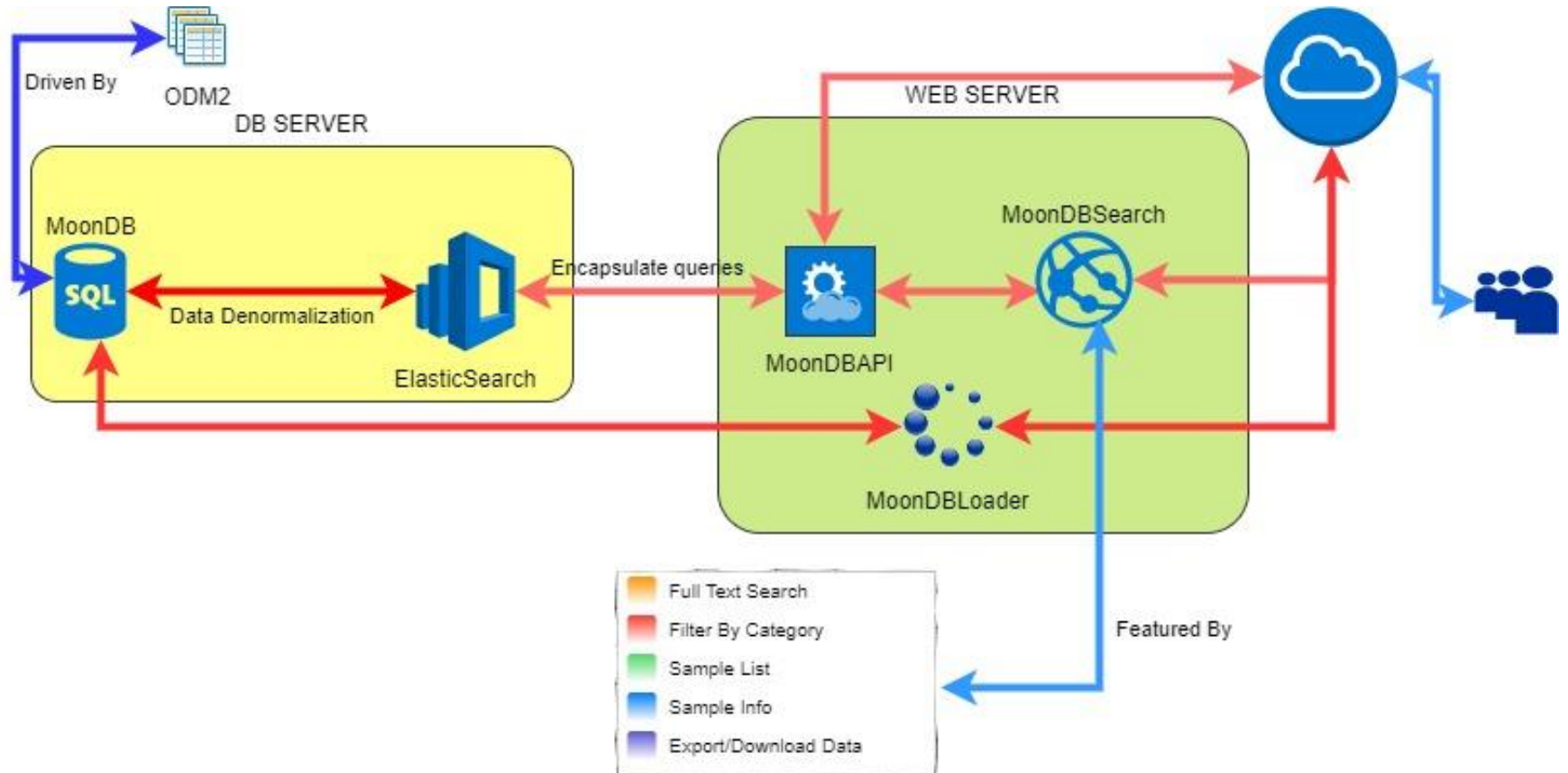
MOONDB SYSTEM ARCHITECTURE



MOONDB SYNTHESIS = DATA FUSION

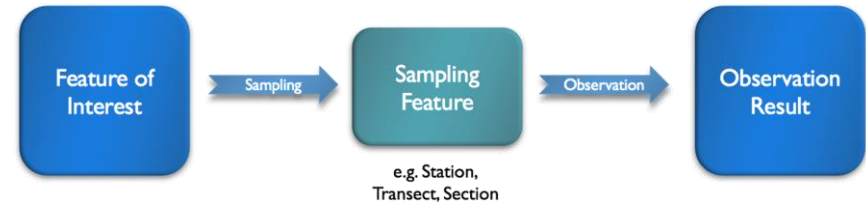
- **FACILITATE DATA MINING & ANALYSIS**
- INDIVIDUAL VALUES STORED IN RELATIONAL DATABASE
- RICH CONTEXT & PROVENANCE METADATA FOR SEARCH AND FILTER
- HARMONIZED AND QUALITY CONTROLLED DATA & METADATA
- DATA OUTPUT ALLOWS IMMEDIATE DATA ANALYSIS
 - USER GENERATED NEW DATA COMPILATIONS ACROSS ANY NUMBER OF DATA SETS
 - DOWNLOAD SPREADSHEETS WITH ALL CONTEXT & PROVENANCE INFORMATION
 - DISPARATE DATA ACQUIRED ON THE SAME SAMPLE INTEGRATED INTO COHERENT SAMPLE DATASETS

MOONDB SYSTEM ARCHITECTURE



MOONDB DATA MODEL

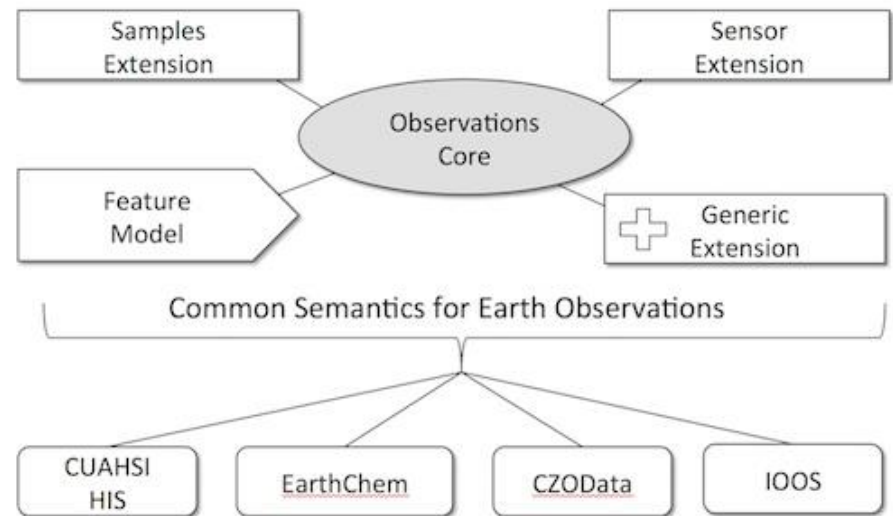
- BASED ON ISO19156
“OBSERVATION & MEASUREMENTS”



- MODIFIED VERSION OF ODM2 (OBSERVATION DATA MODEL)
 - CORE ENTITIES & EXTENSIONS
 - CONTROLLED VOCABULARIES

<https://github.com/ODM2>

<http://vocabulary.odm2.org>



MOONDB API

- RESTFUL SERVICE, USING EXPRESS FRAMEWORK

```
{
  "specimenCode": "10020",
  "specimenName": "10020",
  "parentSpecimen": null,
  "childSpecimens": [ ... ], // 61 items
  "specimenType": "ROCK/Basalt/Ilmenite Basalt",
  "samplingTechnique": null,
  "mission": "Apollo 11",
  "landmark": null,
  "lunarStation": null,
  "returnContainer": "ALSRC 1004",
  "weight": "425.000 g",
  "pristinity": "27.881%",
  "pristinityDate": "2/19/2015",
  "description": "low K, fine-grained, subophitic to
}

"dataResults": [
  {
    "unit": "wt%",
    "method": "EMP",
    "laboratory": "GEOLOGICAL SURVEY OF CANADA",
    "variable": "TiO2",
    "methodComment": null,
    "value": "21.9"
  },
  { ... }, // 6 items
  { ... }, // 6 items
  { ... }, // 6 items
  { ... }, // 6 items
  { ... } // 6 items
]
```

The MoonDB API

Specimen

URL	Description	Parameters	Example
/specimen/{specimenCode}	Get single specimen with basic meta data		http://api.moondb.org/specimen/12023,155_7A
/specimenlist/mission/{missionName}	Find specimens with basic meta data by mission name		http://api.moondb.org/specimenlist/mission/Apollo 11
/specimenlist/landmark/{landmarkName}	Get specimens with basic meta data by landmark name		http://api.moondb.org/specimenlist/landmark/SPUR CRATER
/specimenlist/specimentype/{specimenType}	Get specimens with basic meta data by specimen type		http://api.moondb.org/specimenlist/specimentype/Regolith Breccia
/specimenlist/samplingtechnique/{samplingTechnique}	Get specimens with basic meta data by sampling technique		http://api.moondb.org/specimenlist/samplingtechnique/Rake

AnalysisResults

URL	Description	Parameters	Example
/data/specimen/{specimenCode}	Find analysis results by specimen code		http://api.moondb.org/data/specimen/12023,155_7A
/data/analyzedMaterial/{analyzedMaterial}	Find analysis results by analyzed material		http://api.moondb.org/data/analyzedmaterial/LEACH
/data/citation/{citationCode}	Find analysis results by citation		http://api.moondb.org/data/citation/AGRELL, 1970
/data/{filter}	Find analysis results by combined filter conditions including mission, landmark, specimenType, samplingTechnique, analyzedMaterial, analyte and analysisMethod	{filter} is JSON object like {"mission": [], "landmark": [], "specimenType": [], "samplingTechnique": [], "analyzedMaterial": [], "analyte": [], "analysisMethod": []}	<a [\"breccia\"],="" [\"emp\",="" [\"sio2\",="" [\"zircon\",="" [],="" \"analysismethod\":="" \"analyte\":="" \"analyzedmaterial\":="" \"cao\"],="" \"glass\"],="" \"landmark\":="" \"samplingtechnique\":="" \"sims\"]}"="" \"specimentype\":="" href="http://api.moondb.org/data/{\" mission\":="">http://api.moondb.org/data/{\"mission\": [], \"landmark\": [], \"specimenType\": [\"Breccia\"], \"samplingTechnique\": [], \"analyzedMaterial\": [\"ZIRCON\", \"GLASS\"], \"analyte\": [\"SiO2\", \"CaO\"], \"analysisMethod\": [\"EMP\", \"SIMS\"]}

Authorities

URL	Description	Parameters	Example
/authorities/missions	Find missions		http://api.moondb.org/authorities/missions
/authorities/landmarks	Find landmarks		http://api.moondb.org/authorities/landmarks
/authorities/people	Find people		http://api.moondb.org/authorities/people
/authorities/citations	Find citations		http://api.moondb.org/authorities/citations
/authorities/datasets	Find datasets		http://api.moondb.org/authorities/datasets

Controlled Vocabularies

URL	Description	Parameters	Example
/cv/specimentypes	Find specimen types		http://api.moondb.org/cv/specimentypes
/cv/samplingtechniques	Find sampling techniques		http://api.moondb.org/cv/samplingtechniques
/cv/analyzedmaterials	Find analyzed materials		http://api.moondb.org/cv/analyzedmaterials
/cv/analytes	Find analytes		http://api.moondb.org/cv/analytes
/cv/analysismethods	Find analysis methods		http://api.moondb.org/cv/analysismethods

MOONDB SEARCH

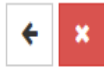
- SEARCH GUI: JAVASCRIPT/ANGULAR
 - FACETED & FREE-TEXT SEARCH
 - WIDE RANGE OF SEARCH CRITERIA
 - SEARCH RESULTS IN TABULAR FORM, INTEGRATING DATA ACROSS DATASETS, DOWNLOAD OPTION (.CSV)

The screenshot displays the MoonDB Search interface. On the left, there are navigation tabs for 'MoonDB Search', 'Data Holdings', and 'APIs'. Below these is a search bar and a sidebar with filter categories: Missions, Landmarks, Specimen Types, Analyzed Materials, Analysis Methods, and Analytes. The 'Specimen Types' filter is expanded, showing 'COMPOSITE', 'METEORITE', 'ROCK', and 'SOIL' (which is selected). The 'Filters Summary' panel shows 'Missions: Apollo 12' and 'Specimen Types: SOIL'. There are 'RETRIEVE DATA' and 'EXPORT TO CSV' buttons. The main area contains a table with 17 columns: analysisCode, analyzedMaterial, comment, dataset, citation, methodCode, methodName, laboratory, methodComment, SiO2, TiO2, Al2O3, FeO, MnO, MgO, and CaO. The table lists six rows of data for Apollo 12 soil samples.

analysisCode	analyzedMaterial	comment	dataset	citation	methodCode	methodName	laboratory	methodComment	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO
12037,20#3#0659	GLASS	TYPE E	MARVIN, 1971#TABLE 3	MARVIN, 1971	EMP	ELECTRON MICROPROBE	SMITHSONIAN INSTITUTION OF WASHINGTON		60.7	0.3	20.5	0.2	0.0	0.2	3.5
12037,20#4#0659	WHOLE ROCK	115-1	MARVIN, 1971#TABLE 4	MARVIN, 1971	EMP	ELECTRON MICROPROBE	SMITHSONIAN INSTITUTION OF WASHINGTON		46.7	2.4	22.4	6.9	0.1	7.1	12.1
12037,20#5#0659	WHOLE ROCK	115-2	MARVIN, 1971#TABLE 4	MARVIN, 1971	EMP	ELECTRON MICROPROBE	SMITHSONIAN INSTITUTION OF WASHINGTON		54.6	2.0	19.5	8.5	0.1	4.1	9.3
12037,20#6#0659	WHOLE ROCK	115-3	MARVIN, 1971#TABLE 4	MARVIN, 1971	EMP	ELECTRON MICROPROBE	SMITHSONIAN INSTITUTION OF WASHINGTON		42.7	4.2	16.4	11.5	0.1	4.6	12.2
12037,20#7#0659	WHOLE ROCK	115-4	MARVIN, 1971#TABLE 4	MARVIN, 1971	EMP	ELECTRON MICROPROBE	SMITHSONIAN INSTITUTION OF WASHINGTON		45.0	0.4	30.2	2.4	0.0	6.4	15.3
12037,20#8#0659	WHOLE ROCK	115-5	MARVIN, 1971#TABLE 4	MARVIN, 1971	EMP	ELECTRON MICROPROBE	SMITHSONIAN INSTITUTION OF WASHINGTON		50.4	0.6	18.3	9.0	0.1	9.7	10.0

INTEROPERABILITY: LINKING FEATURES & SAMPLES IN MOONTREK

Shorty



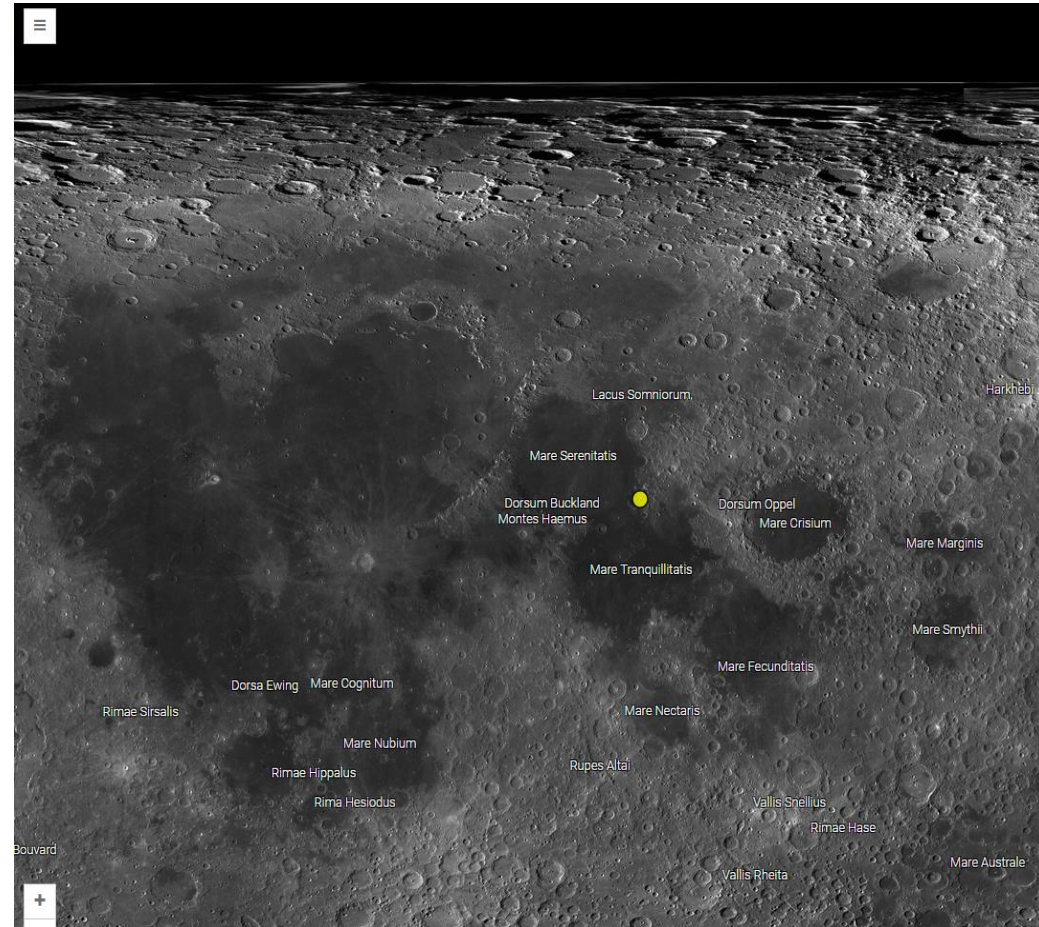
Item Type	Nomenclature
Name	Shorty
Diameter	0
Latitude	20.2
Longitude	30.6
Origin	Astronaut-named feature, Apollo 17 site.
Ethnicity	American
Type	Landing site name
Additional Info	http://planetarynames.wr.usgs.gov/Feature/5500

MoonDB Specimens

74220, 70

74001, 1217

74001, 1218



MOONDB CONTENT

of Datasets

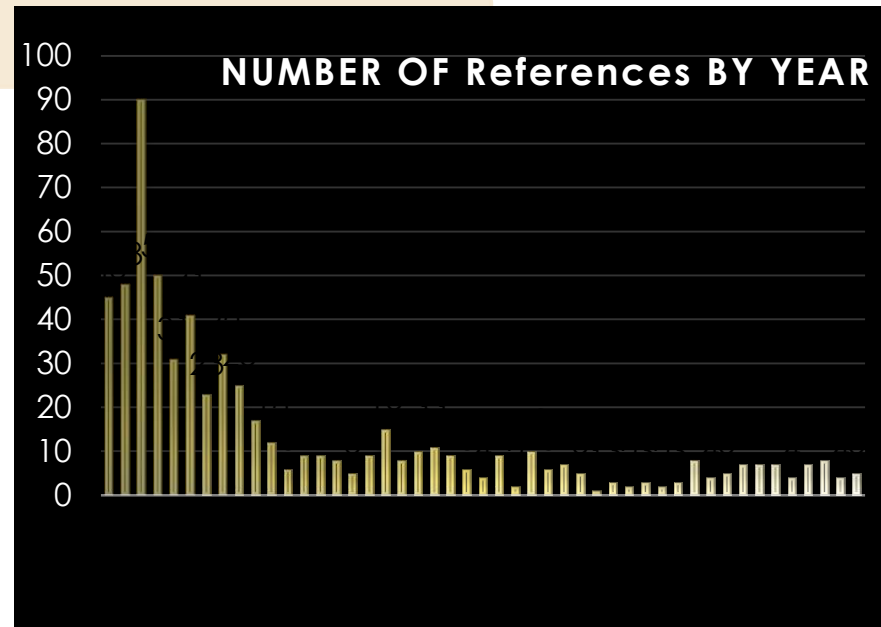
• 642

of Specimens

• 13,996

of Data Points

• 598,806



MOONDB DATA CURATION

- DEDICATED DATA MANAGER COMPILES AND FORMATS DATA & METADATA
 - FOLLOWING BEST PRACTICES FOR GEOCHEMICAL DATA FOR METHOD & DATA QUALITY DESCRIPTION
 - HARMONIZING VOCABULARIES / CLASSIFICATIONS AGREED ON WITH JSC
 - SPECIAL ATTENTION TO SAMPLE IDENTIFIERS AND LINKING SAMPLES AND SUBSAMPLES
- DATA & METADATA ARE INGESTED INTO MOONDB USING PHP SCRIPTS (MOONDBLOADER)
 - PERFORM DATA VALIDATION
 - LINK NEW DATA TO SAMPLES ALREADY IN MOONDB VIA UNIQUE IDENTIFIERS

MOONDB: DATA PUBLICATION VIA THE EARTHCHEM LIBRARY

- TRUSTED REPOSITORY FOR USER CONTRIBUTIONS
 - WORLD DATA SYSTEM MEMBER, CORETRISTSEAL CERTIFICATION UNDER WAY
 - DOI REGISTRATION
- LINKS TO PUBLICATIONS
- LINKS TO FUNDING AWARDS

HOME ABOUT BIBLIO TEAM CONTRIBUTE DATA TO MOONDB MOONDB SEARCH

Submit MoonDB Data

GeoPass

One GeoPass ID gets you into multiple geoinformatics systems.

- EarthChem Portal
- EarthChem Library
- IEDA Data Management Plan tool
- Marine Geoscience Data System (MGDS)
- System for Earth Sample Registration (SESAR)
- USAP Data Center

GeoPass ID

Password

Remember me

Don't have a GeoPass ID? [Sign up now!](#)
[Forgot/Change your password?](#)

<http://www.moondb.org/submit>



Climate dependence of feldspar weathering in shale soils along a latitudinal gradient

Ashlee L. Dere^a, Timothy S. White^{a, b}, Richard H. April^c, Brian Reynolds^d, Thomas E. Miller^e, Elizabeth P. Knapp^f, Larry D. McKay^g, Susan L. Brantley^{a, b}

Show more

<http://dx.doi.org/10.1016/j.gca.2013.08.001>

IGSN: SSH000STR



IGSN: SSH000STR
Sample Name: ald-10-01
Other Name(s):
Sample Type: Individual Sample
Parent IGSN: Not Provided

Description

Material: Rock
Classification: Not Provided
Field Name: shale
Description: rock outcrop sample
Age (min): Not Provided
Age (max): Not Provided
Collection Method: rock hammer
Collection Method Description: Not Provided
Size: Not Provided
Geological Age: Not Provided
Geological Unit: Not Provided
Comment: Not Provided
Purpose: CZO Shale Transect

Geolocation

Latitude: 52.470683
Longitude: -3.69255
Elevation: 323.088
Nav Type: Not Provided
Physiographic Feature: stream bed
Name Of Physiographic Feature: Not Provided
Location Description: Plynlimon forest, Wales, shale Severn stream bed
Locality: Not Provided
Locality Description: Not Provided
Country: United Kingdom
State/Province: Wales
County: Not Provided
City: Not Provided

Collection

Table 2.

Major elemental chemistry of shale collected across the transect and corresponding depth of sample (d) where applicable. All rock samples were collected at local outcrops with the exception of PlynQ-RF and ALD-10-158, which were recovered from the bottom of soil pits and ALD-10-152, which is a weathered shale chip recovered from the bottom of the augered core.

Site	Sample name	IGSN ^a	d (m)	Al (%)	Ca (%)	Fe (%)	K (%)	Mg (%)	Mn (%)	Na (%)	P (%)	Si (%)	Ti (%)	Zr (ppm)
Wales	PlynQ-RF	SSH000JGG	0.35	12.0	0.04	6.77	3.15	1.41	0.43	0.57	0.04	25.1	0.82	164
	ALD-10-01	SSH000STR		11.8	0.03	6.40	2.96	1.36	0.33	0.68	0.04	26.3	0.82	154
	ALD-10-02	SSH000STS		11.0	0.01	5.77	2.88	1.23	0.21	0.61	0.04	27.1	0.71	137
	ALD-10-03	SSH000STT		11.8	0.01	6.73	2.87	1.47	0.23	0.62	0.05	24.4	0.90	175
	ALD-10-04	SSH000STU		11.6	0.05	6.45	2.66	1.63	0.13	0.77	0.06	25.9	0.83	215
	ALD-10-06	SSH000STW		11.9	0.05	6.17	2.91	1.53	0.21	0.76	0.06	24.8	0.85	186
	ALD-10-07	SSH000STX		11.7	0.01	6.45	2.93	1.33	0.29	0.62	0.05	24.3	0.90	210
	ALD-10-08	SSH000STY		11.9	0.02	6.82	2.94	1.50	0.62	0.62	0.06	24.9	0.89	185
	ALD-10-09	SSH000STZ		11.2	0.07	6.51	2.77	1.41	0.27	0.64	0.06	24.1	0.84	167
	ALD-10-33	SSH000SUO		11.7	0.04	6.32	2.97	1.41	0.21	0.64	0.06	24.1	0.85	165

COMING SOON: LINKING SAMPLES, DATA, & PUBLICATIONS VIA IGSN

MOONDB PHASE 2

- RESTORATION OF LUNAR METEORITE DATA
 - ADD GEOCHEMICAL, PETROLOGICAL, MINERALOGICAL, AND GEOCHRONOLOGICAL DATA OF LUNAR METEORITES TO THE MOONDB SYNTHESIS
- RESTORATION OF LUNAR GEOCHRONOLOGICAL DATA
 - COMPILE AND INGEST GEOCHRONOLOGICAL DATA FOR BOTH THE APOLLO SAMPLE SUITE AND LUNAR METEORITES INTO THE MOONDB SYNTHESIS
- INTEGRATION WITH THE PLANETARY DATA SYSTEM (PDS)
 - ARCHIVE MOONDB DATA IN THE PDS'S CARTOGRAPHY AND IMAGING SCIENCES NODE
 - MAKE THEM AN INTEROPERABLE RESOURCE FOR THE INTERNATIONAL PLANETARY SCIENCE COMMUNITY
- BUILDING THE MOONDB USER COMMUNITY
 - BUILD AND FOSTER AN ACTIVE MOONDB USER COMMUNITY THAT CONTRIBUTES TO ENSURING AND GROWING THE UTILITY OF MOONDB'S SERVICES AND QUALITY OF ITS DATA HOLDINGS.
- STARTED MARCH 1, 2018

MOONDB PHASE 2: ARCHITECTURE

