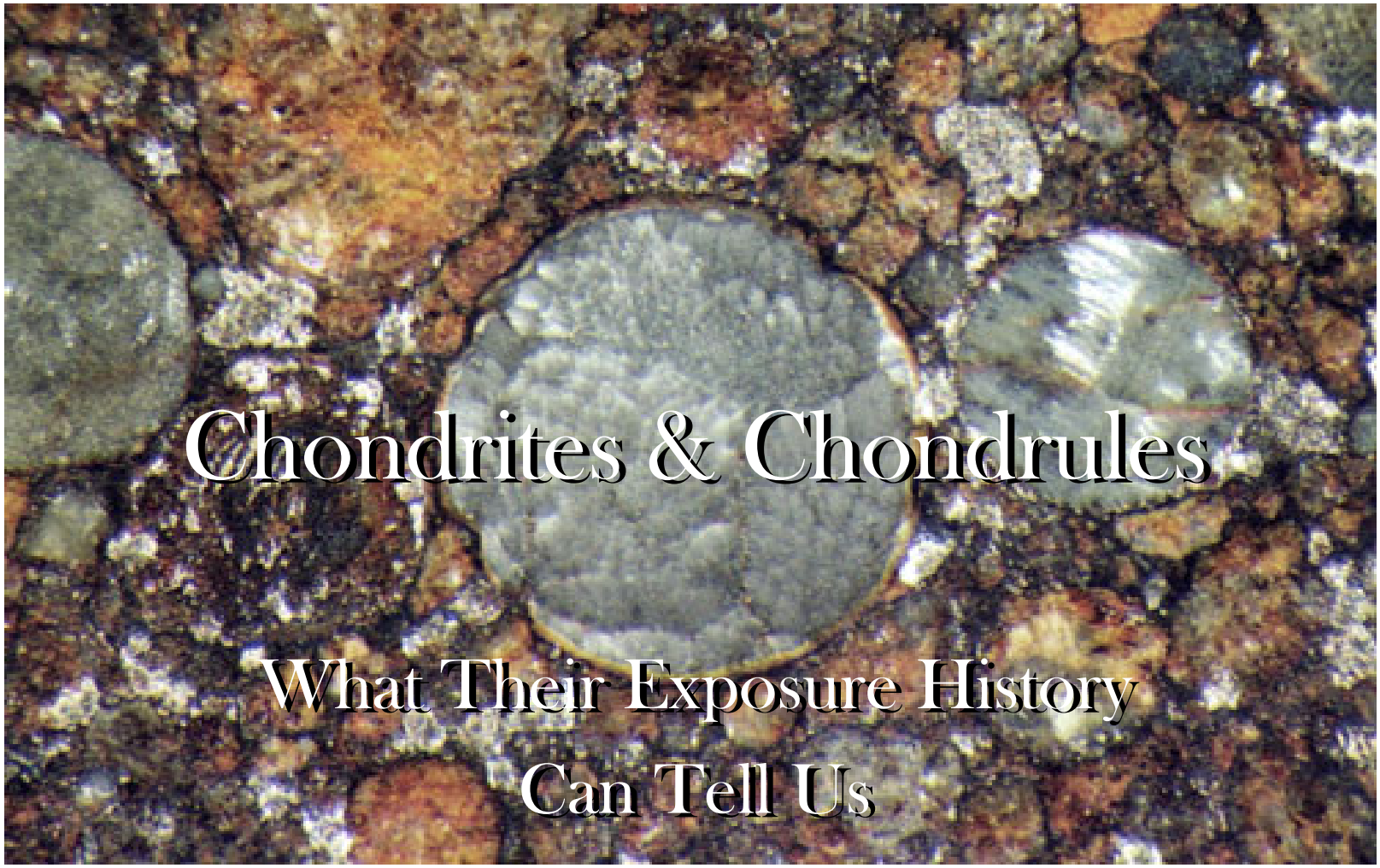

Chondrites & Chondrules

What Their Exposure History Can Tell Us

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Physics REU Presentation

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Chondrites – Primitive Meteorites

- Meteorites containing roughly spherical inclusions called Chondrules
- Primitive because they are compositionally similar to the sun – thus a piece of the early solar system – before major differentiation
- Account for approximately 86% of recovered meteorites – upwards of 27,000
- Many different types of Chondrites exist

Chondrules

- Spherical crystalline inclusions in Chondrites
- Exhibit widely varying crystal structures indicative of Chondrite type
- Range in size from 0.02mm to 10 mm also indicative of Chondrite type

Formation of Chondrules

- It is known that Chondrules form through heating to make them liquid and then a very fast cooling to preserve the spherical shape of the liquid droplet
- How this transpires is a complete mystery with dozens of different theories about the process
- One hypothesis has chondrules forming due to a phenomenon known as the X-wind

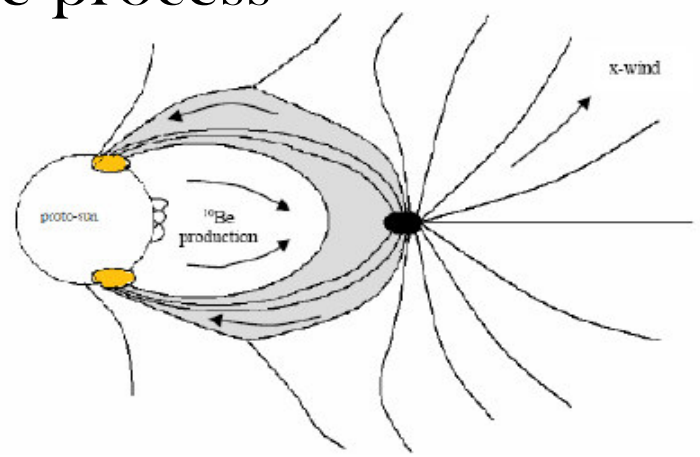


Figure 25 Magnetic field geometry for ^{10}Be spallation production. The gray area illustrates accretion flow along magnetic field lines onto the proto-sun, terminating in accretion "hot-spots" at high altitudes on the PMS star. ^{10}Be produced close to the surface is implanted in CAI precursor material and transported to asteroidal distances via the x-wind. (Figure after Shu et al, 1997)

Overall Goal

- Analyze cosmogenic nuclides which have formed by spallation in the Chondrules of the meteorite
- Use these to get an idea about both the history of the meteorite and the history of how active our sun was during the early solar system in terms of producing cosmic rays
- To do this we need to make three separate measurements of each individual chondrule

Stable Nuclides

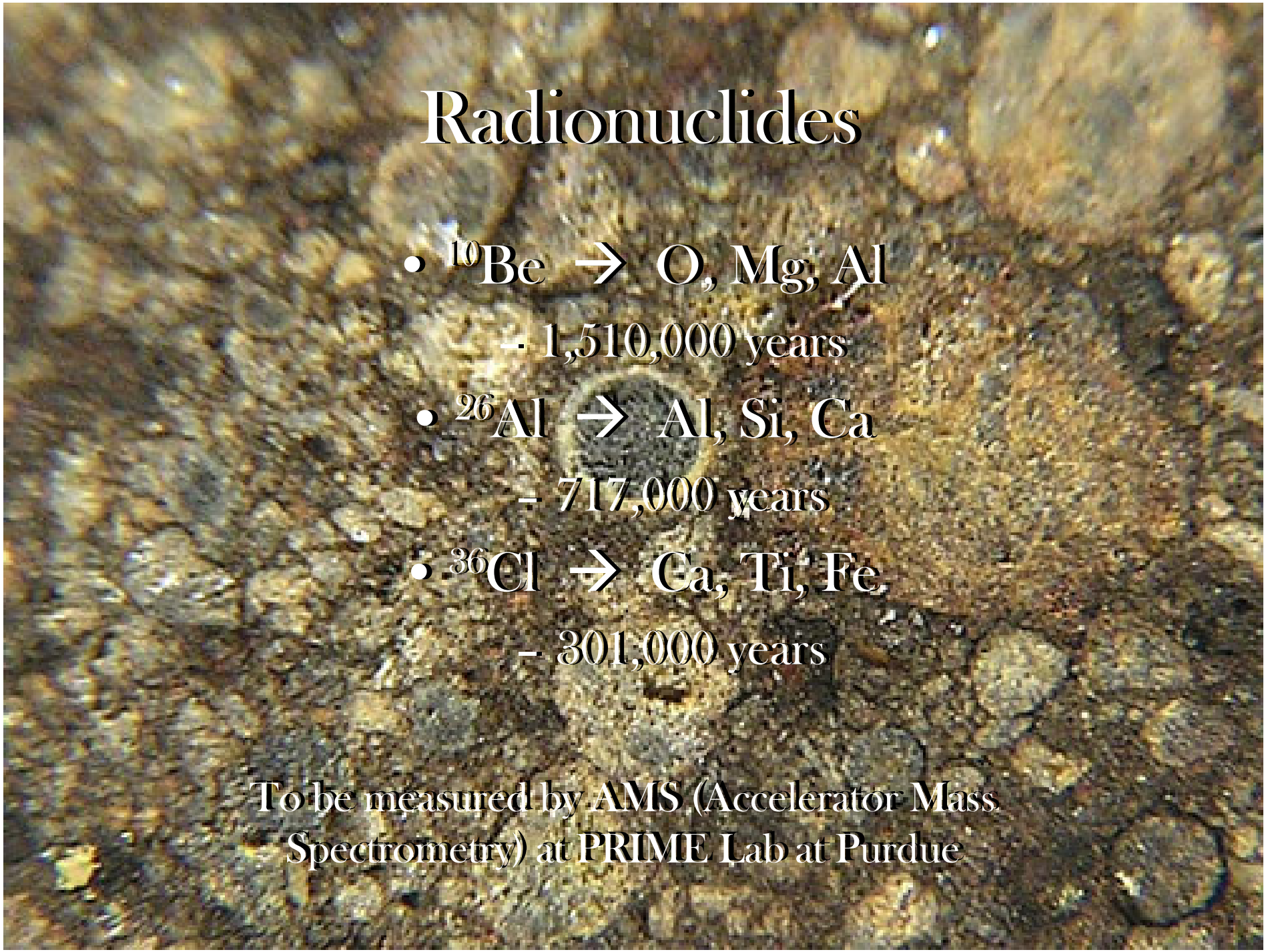
Cosmogenic Noble Gases Analyzed

- He, Ne, Ar, Kr, Xe

Target Production Elements

- Mg, Si, Fe, Ca

To be measured by Noble Gas Mass Spectrometry
at Washington University in St. Louis



Radionuclides

- ^{10}Be → O, Mg, Al
  - 1,510,000 years
- ^{26}Al → Al, Si, Ca
  - 717,000 years
- ^{36}Cl → Ca, Ti, Fe
  - 301,000 years

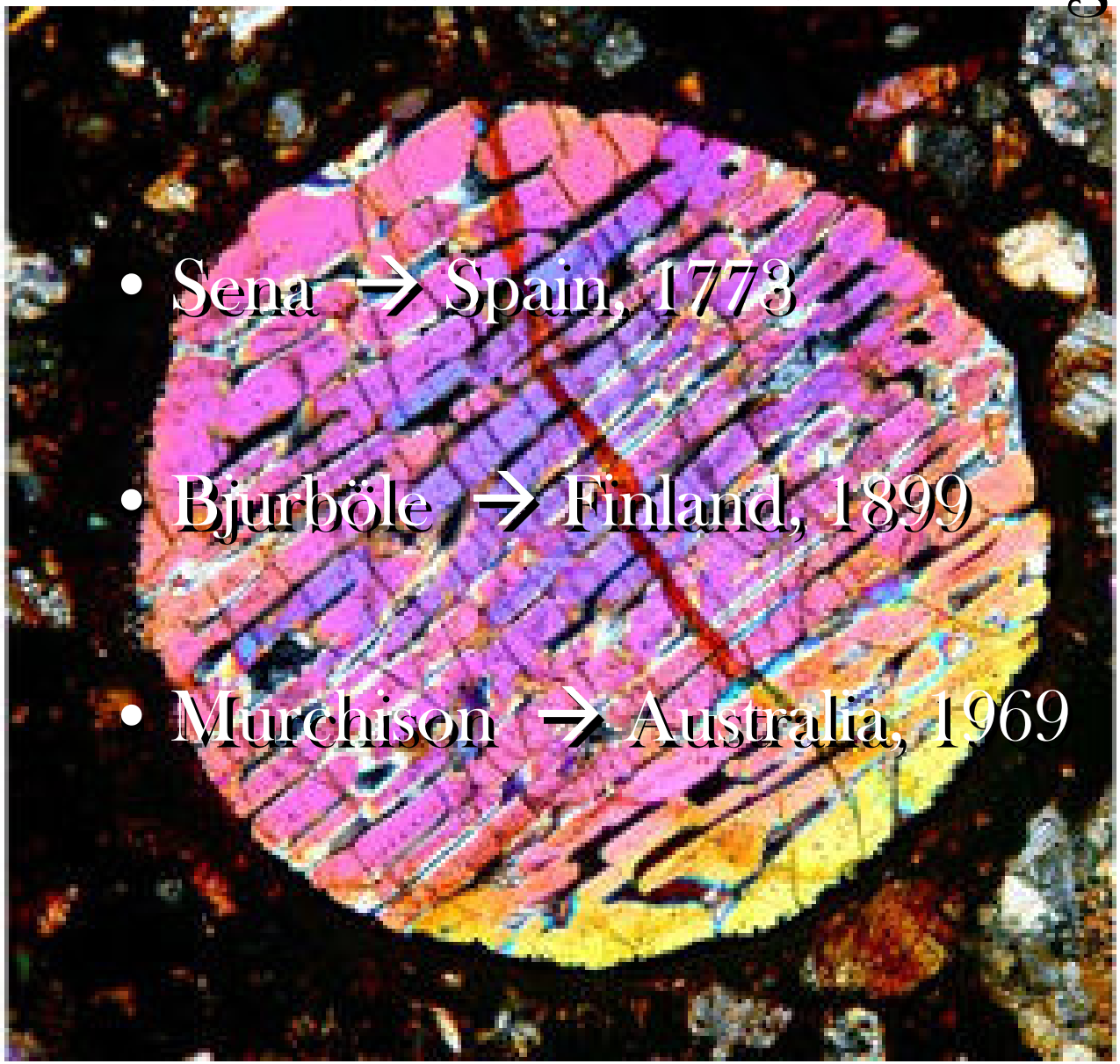
To be measured by AMS (Accelerator Mass Spectrometry) at PRIME Lab at Purdue

Bulk Chemical Composition of Chondrules

- Measurements were taken for the elements
  - Aluminum, Beryllium, Calcium, Iron, Potassium, Magnesium, Manganese, Sodium, Nickel, Lead, Phosphorus, Titanium, and Zinc
- Calculations were performed for the elements
  - Silicon & Oxygen

Measurements have been taken using ICP-OES (Inductively Coupled Plasma – Optical Emission Spectrometry) at PRIME Lab at Purdue

Meteorites I am Examining



- Sena → Spain, 1778
- Bjurböle → Finland, 1899
- Murchison → Australia, 1969

Percent Composition of Chondrules from Bjurböle, Murchison & Sena

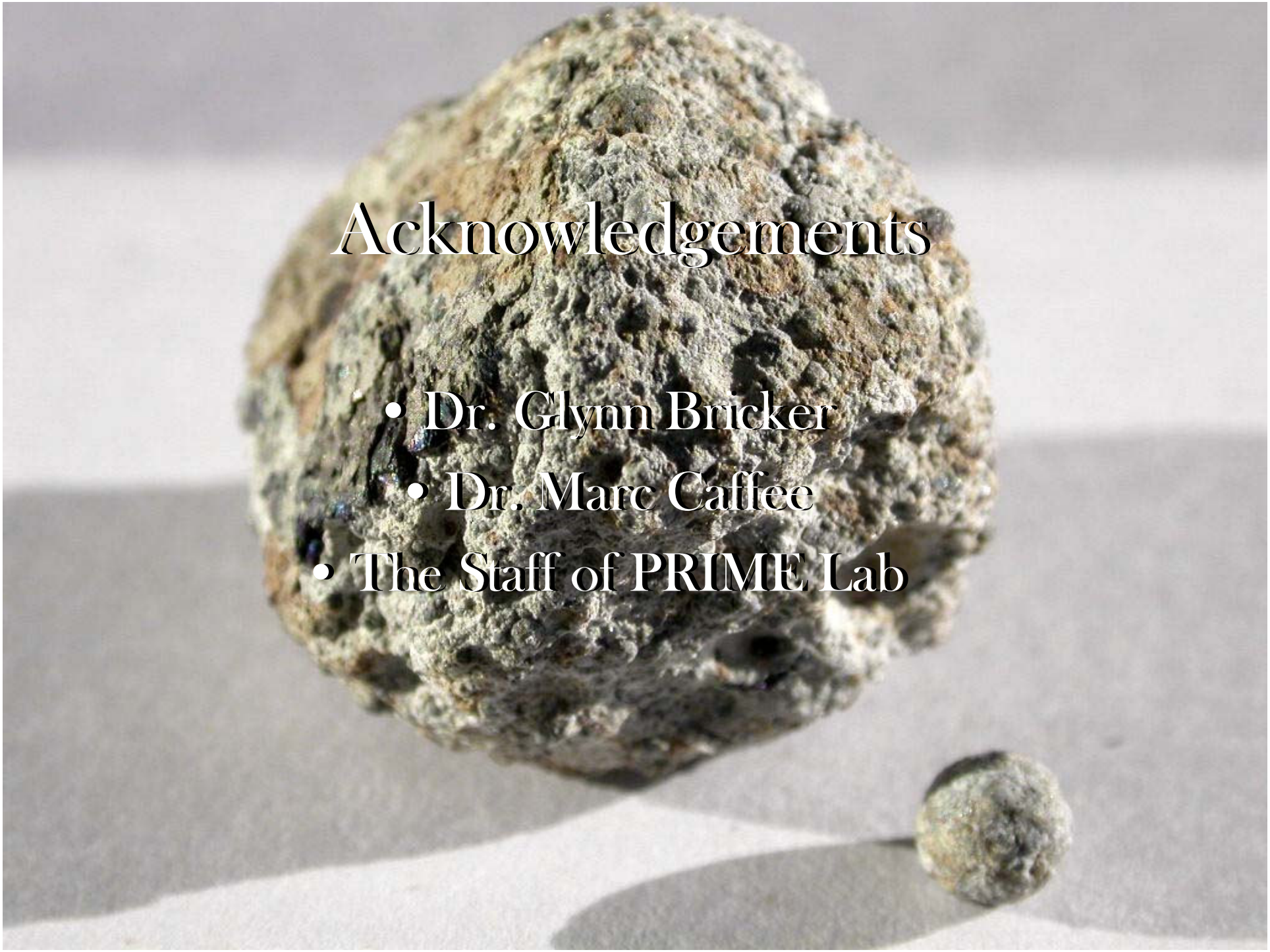
	Al	Be	Ca	Fe	K	Mg	Mn	Na	Ni	P	Ti	Zn	O	Si
BC20 A	1.46	0.00	1.40	12.80	0.12	10.03	0.21	0.67	1.78	0.05	0.07	0.03	44.08	27.29
BC20 B	2.31	0.00	1.45	25.89	0.10	13.15	0.28	0.79	2.54	0.07	0.10	0.03	37.66	15.64
BC20 C	1.39	0.00	1.95	23.55	0.10	10.39	0.22	0.62	2.57	0.04	0.06	0.04	39.24	19.84
BC21 A	0.60	0.02	1.01	7.18	0.06	4.67	0.14	0.30	1.48	0.01	0.03	0.02	48.11	36.35
SC01 A	1.50	0.02	2.52	14.33	0.17	16.61	0.32	0.88	0.65	0.06	0.05	0.03	41.92	20.93
SC02 A	1.29	0.08	2.05	7.87	0.27	3.33	0.16	0.89	0.65	0.07	0.04	0.05	47.69	35.56
SC03 A	5.11	0.21	9.16	25.28	0.42	10.87	0.56	1.77	2.62	0.04	0.09	0.11	34.81	8.93
MC01 A	1.79	0.20	2.84	37.25	0.22	7.69	0.59	0.94	3.93	0.07	0.07	0.09	33.18	11.13

Compositional Examination of Sena Chondrules and Matrix

	Al	Be	Ca	Fe	K	Mg	Mn	Na	Ni	P	Ti	Zn	O	Si
SC01 A	1.50	0.02	2.52	14.33	0.17	16.61	0.32	0.88	0.65	0.06	0.05	0.03	41.92	20.93
SC02 A	1.29	0.08	2.05	7.87	0.27	3.33	0.16	0.89	0.65	0.07	0.04	0.05	47.69	35.56
SC03 A	5.11	0.21	9.16	25.28	0.42	10.87	0.56	1.77	2.62	0.04	0.09	0.11	34.81	8.93
SC ave	2.63	0.10	4.58	15.83	0.29	10.27	0.35	1.18	1.31	0.06	0.06	0.06	41.47	21.81
SM02	1.92	0.00	1.82	38.88	0.12	18.24	0.51	0.63	6.81	0.22	0.08	0.05	29.40	1.32

Disaggregator

- We wanted to examine chondrules from a few other chondrites such as Bovedy and Kalvesta, however first we need to extract the chondrules intact
- We wanted to use an automated freeze thaw disaggregation method however there were some issues



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