

Chasing Earthquakes in California

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Summary

We propose an instrument and a method to observe and study unfolding earthquakes in granular media, such as an underground sand pool.

Preliminary observations over the past 30 years suggest that the underground sand pool exhibits dynamics of granular media, with force chain pattern changes before large ($M_s > 5.0$) nearby (within 100 km) earthquakes.

After 4 years of preparation, a father-and-son team sets out to chase after big earthquakes in California.

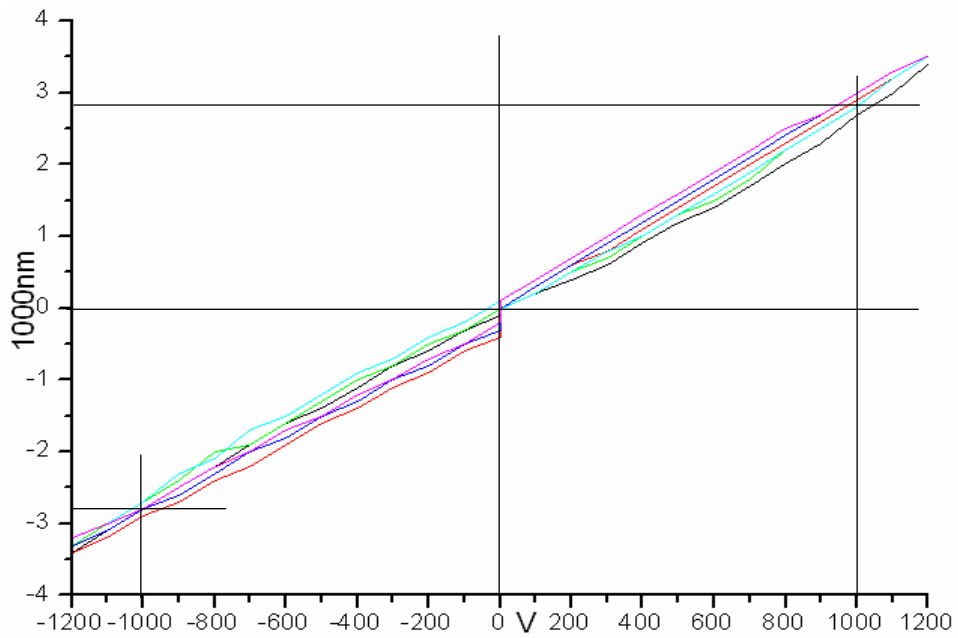
Keywords: earthquake, granular media, force chain pattern.

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** Hong Sun is a system design engineer working in Bay Area.



Above sensor system measures displacement as little as 1 nm.



BaTiO₃'s crystal lattice deforms under electric field with known property, which is used as calibration scale for the sensor.

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测试结果

No.1

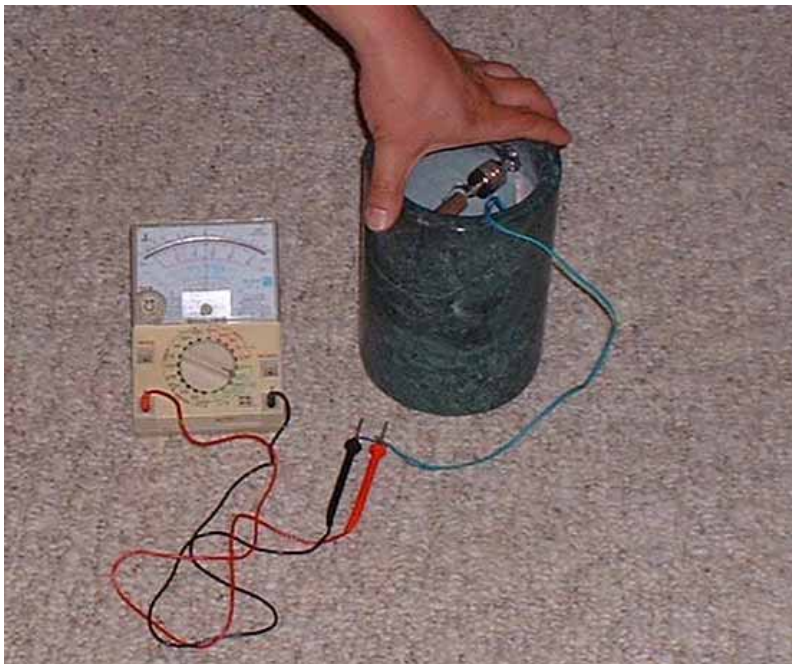
位移 (mm)	电阻 (kΩ)	位移 (mm)	电阻 (kΩ)	位移 (mm)	电阻 (kΩ)	位移 (mm)	电阻 (kΩ)
0.0	70	0.0	42	0.0	51	0.0	52
0.1	20	0.2	37	0.1	42	0.2	29
0.3	26	0.4	28	0.6	37	0.4	17
0.3	23	0.4	20	0.8	29	0.7	15
0.9	17	0.6	9	1.9	24	0.9	12
0.7	10	1.0	5.3	1.2	12	1.2	8
1.3	6.4	1.6	2.3	1.7	9	1.6	2
1.7	5.1	2.2	2.2	2.2	9	2.0	1.2
2.0	5.1						
2.7	2.3						

No.2

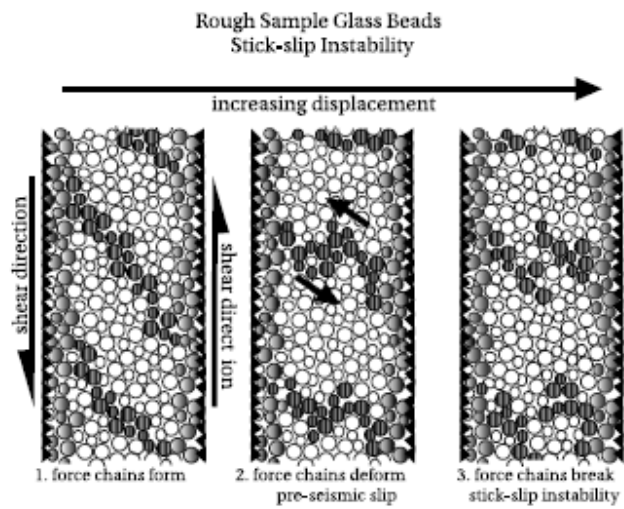
位移 (mm)	电阻 (kΩ)	位移 (mm)	电阻 (kΩ)	位移 (mm)	电阻 (kΩ)	位移 (mm)	电阻 (kΩ)
0.0	33	0.0	7.0	0.0	18.0	0.0	16
0.2	32	0.2	6.0	0.2	13.0	0.4	12
0.7	32	0.3	5.3	0.3	10.0	0.8	7.3
1.0	17	0.8	4.3	0.6	6.2	1.1	6.0
1.8	13	1.2	3.3	1.0	5.0	1.5	3.6
2.3	6	1.4	2.6	1.5	3.2	2.0	2.3
		2.2	1.8	1.9	2.0	2.3	1.1
		2.4	0.7	2.2	1.3		

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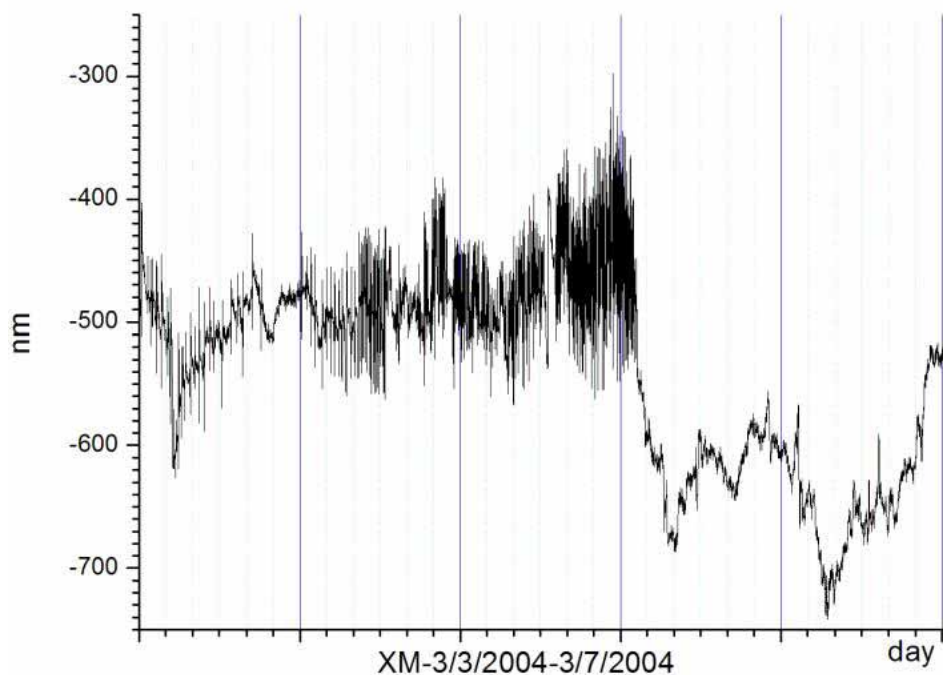
The sensor system was tested by National Institute of Metrology in China in 2004. The serial number of the test report is **CDgs2004-0017**.



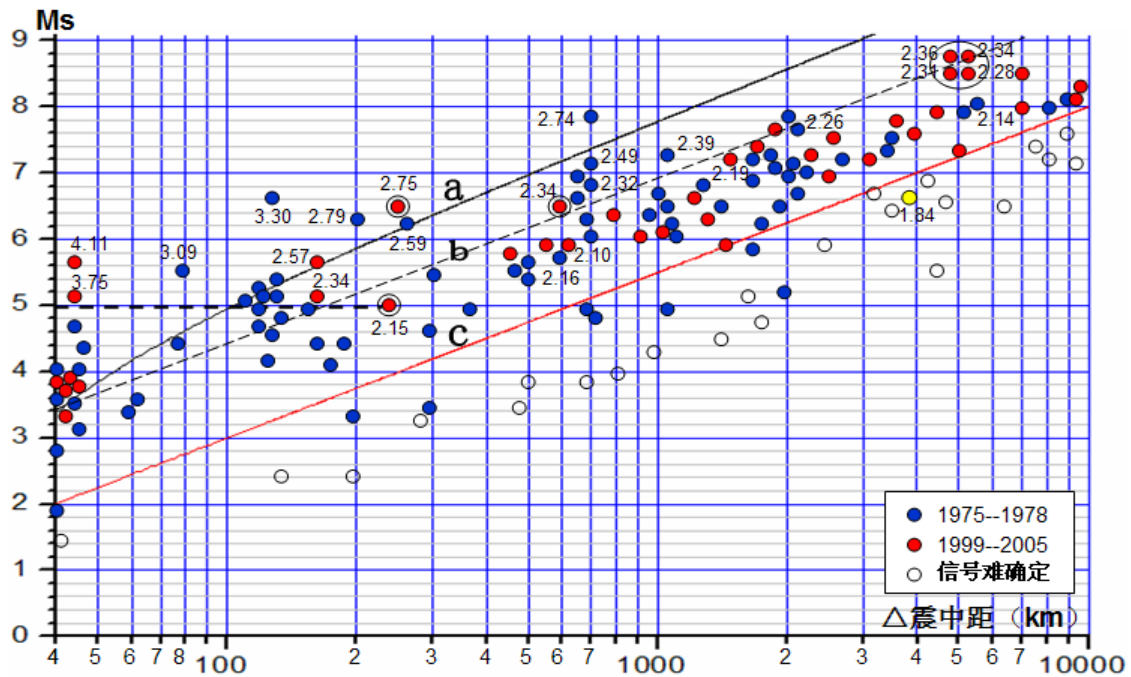
Here is a demo with a sensor mounted in a marble container purchased from *Bed Bath & Beyond*. The marble container deforms slightly (in nm) under hand pressure. A regular multimeter is connected to the sensor, showing resistance of the sensor (in Ohm) varies as the hand pressure changes.



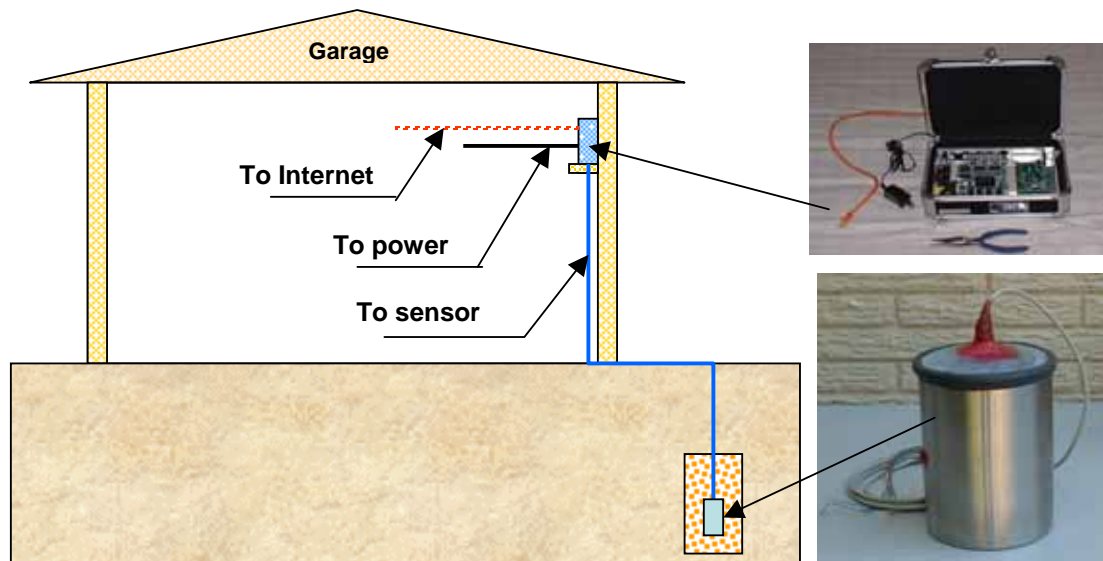
The physics of granular media is under very active studies. We hope that further research in this field could some day provide us a new tool in seismology.



In this example, force chain pattern changed (jamming?) 18 days before an earthquake (Ms 5.9) occurred in Inner Mongolia, 450 km away from the nearest sensor in 2004.



Over the past 30 years, for those earthquakes listed above *line a*, force chain patterns were recorded with observable changes days before the actual earthquakes. More observatories running for a longer period of time are needed to prove or disprove this method.



Here is an example of how the sensor system could be installed in a private home. We are planning to install 4 sensors this year, and 2 more sensors next year in California. Details of this project along with collected data will be released on the Internet under **open source**. We hope that more people could join us in this scientific adventure and have fun ☺