# Arrowsmith blog

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## How do we determine that the recent Chile earthquake was "500 times larger than" the recent Haiti earthquake?

In a lot of the recent news coverage, the February 27, 2010 Chile earthquake was quoted as being 500 times larger than the January 12, 2010 Haiti earthquake. I wanted to remind myself of how they figured that out.

Note that Kim Hannnula has a nice discussion about this problem as well: How big was that EQ? Magnitude vs intensity in Chile and Haiti.

First, one might say, well, if it is a log scale and it is M8.8 for Chile and M7.0 for Haiti, then that is a 1.8 magnitude difference, so what is $10^{1.8}$? Only 63 times larger. So that does not explain it. We have to go back to the more complete explanation of earthquake magnitude. This site has a nice bit of background: Earth 520: Plate Tectonics and People at Portland State University.

The equation for seismic moment is $M_0 = \mu A \bar{u}$ where $\mu$ is the shear modulus (30 GPa or $3\times10^{10}$ N/m$^2$), A is the area of the fault surface which failed (needs to be converted to m2), $\bar{u}$ is average slip over the fault surface (m). This is measured here in units of Newton meters or work (sometimes you see it as dyne-centimeters).

And, once you have the seismic moment in N m, then you may wish to convert it to Moment Magnitude ($M_w$) = $(2/3).*\log_{10}(M_0) - 6.05$

I used this powerpoint (slide 7) from IRIS from their Teachable Moments to determine the areas and mean slip.

Now, let's go through the math (I have written this in Matlab, so I will leave it in that format and one can just copy and paste the whole thing into a Matlab script and run it). This is easy enough that one can also do it on paper.

```
%Constant:
mu = 3.*10.^10;

%Chile Feb 27, 2010 earthquake:
Lc=600.*1000; %600 km long
Wc=150.*1000; %150 km down dip width
U_barc=5; %5 m average slip

chile_seismic_moment = mu.*Lc.*Wc.*U_barc
```

chileMw = (2/3).*log10(chile_seismic_moment) - 6.05

%Haiti
Lh=30.*1000; %30 km long
Wh=10.*1000; %10 km down dip width
U_barh=3; %3 m average slip (fairly high for length–higher stress drop?)

haiti_seismic_moment = mu.*Lh.*Wh.*U_barh
haitiMw = (2/3).*log10(haiti_seismic_moment) - 6.05

howmuchbigger=chile_seismic_moment./haiti_seismic_moment
And, here are the answers:
chile_seismic_moment = 1.3500e+022 Nm
chileMw = 8.7036 (close to what was reported)
haiti_seismic_moment = 2.7000e+019 Nm
haitiMw = 6.9042 (close to what was reported)
**howmuchbigger = 500.0000** (exactly!). But, note that the magnitudes really depend on our estimates of the geometry of the ruptures. Certainly at the order of magnitude, they won't change significantly, and thus this is sensible

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