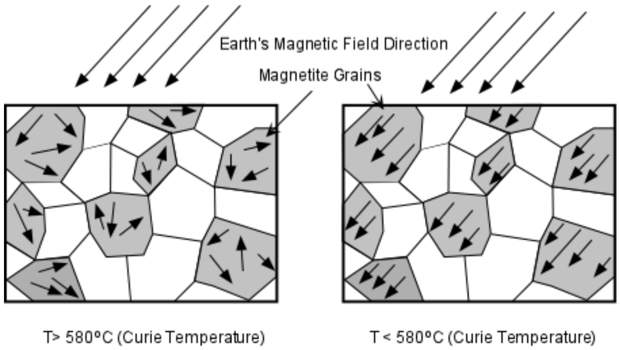
210D5: Magnetization of the crust

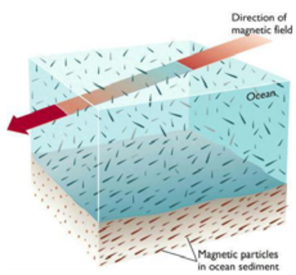
D5.1 Mechanisms for magnetizing crustal rocks

D5.1.1 Thermoremnant magnetization



- spontaneous magnetization when temperature drops below **Curie temperature**
- magnetization cannot change once below **blocking temperature**

D5.1.2 Detrital remnant magnetization

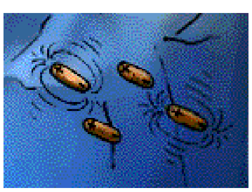


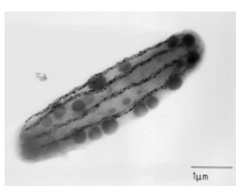
- Detrital magnetization can produce a weak remnant magnetization in sedimentary grains
- grains being deposited contain some magnetite or other magnetic mineral
- preferred orientation as they are deposited

D5.1.3 Chemical remnant magnetization

- Can occur during alteration, diagenesis
- Example from oil field in Gibson and Millegan (1988)

D5.1.4 Magnetic bacterial influences?





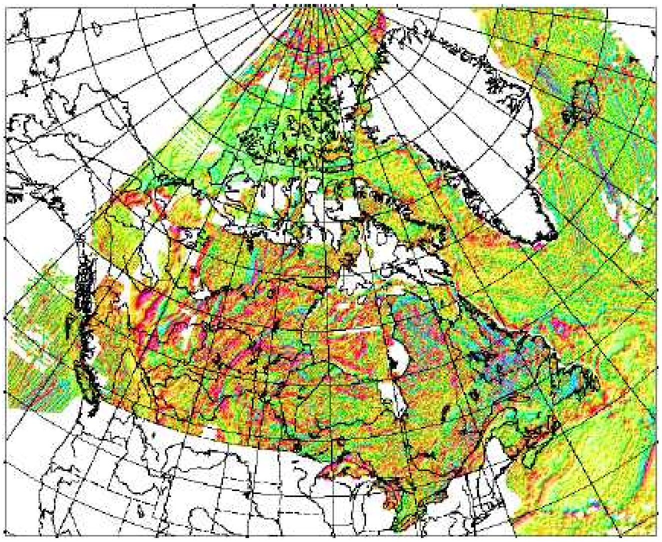
- Magnetotactic bacteria were discovered in 1975 by Blakemore.
- Check the movie at http://www.geophysik.uni-muenchen.de/research/biogeomagnetism
- Both northern and southern hemisphere adapted bacteria exist , with mixture at equator
- Can they produce magnetization in rocks?
- What about geomagnetic reversals?

Other references

- http://www.biophysics.uwa.edu.au/STAWA/magbac_5.html
- http://www.panspermia.org/magneto.htm

D5.2 Continental scale magnetic anomalies

D5.2.1 Aeromagnetic map of Canada



- major features produced by crystalline basement rocks
- variation in magnetic mineral content produces variations in susceptibility
- zones of high susceptibility produce a positive magnetic anomaly
- note magnetic stripes in ocean

D5.2.2 Tibetan Plateau and Himalaya

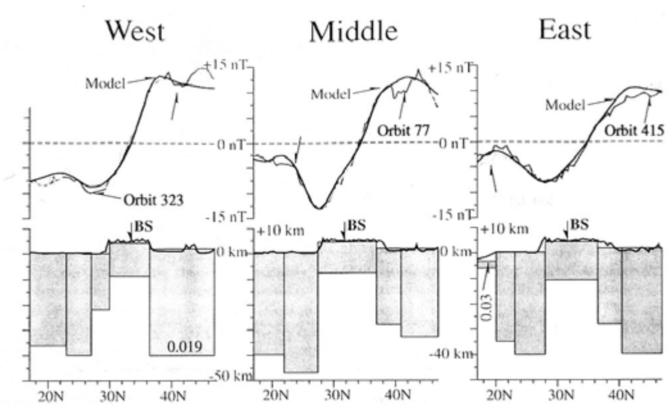
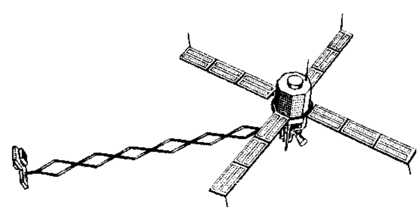


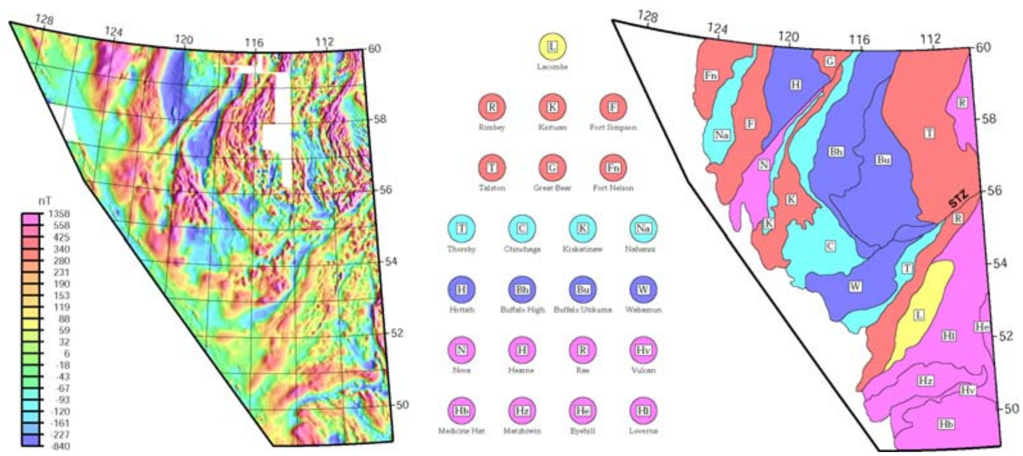
Figure 3. Forward modeling of scalar magnetic anomalies of six Magsat tracks across Tibet (locations shown in Fig. 1). All blocks have model susceptibility of 0.015 cgs (unless otherwise noted). Surrounding white areas have zero susceptibility. Thick black line across top of each model is average elevation along ground tracks of modeled pair of orbits (vertical exaggeration is 46×). BS is Banggong suture. Average satellite altitudes for each pair of orbits are similar, thus limiting continuation differences in anomaly amplitude (orbit 400 = 493 km, 323 = 467 km, 1574 = 355 km, 77 = 386 km, 492 = 518 km, 415 = 498 km). Because of filtering effects, anomaly amplitudes in Figure 1 are less than Figure 3.



- High crustal temperatures cause the **Curie depth** to be shallower than normal below regions with active tectonics. No induced magnetization below Curie depth.
- Example from satellite data MAGSAT from Alsdorf and Nelson (1999)
- More recent satellite data from the Oersted mission

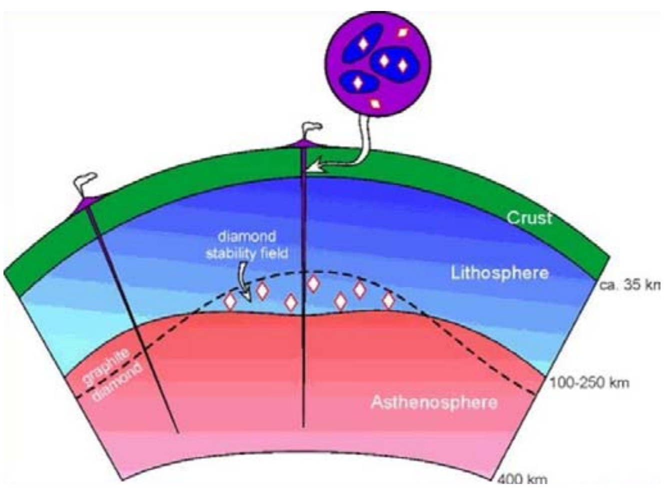
D5.3 Local magnetic anomalies

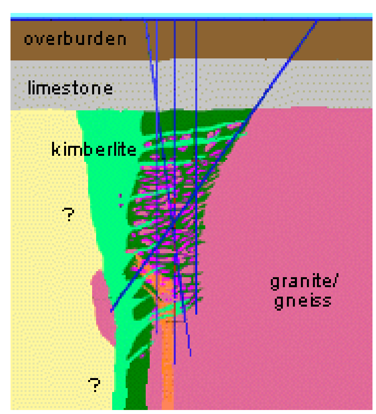
D5.3.1 Magnetic anomalies in Alberta



- Induced magnetization in basement rocks controls overall anomaly pattern.
- This allows mapping in between well where direct sampling is possible
- Maps above and more details in Pilkington et al., (2000)
- Snowbird tectonic zone close to Edmonton
- Vulcan zone in Southern Alberta. Rifting event?

D5.3.2 Aeromagnetic exploration for diamond exploration

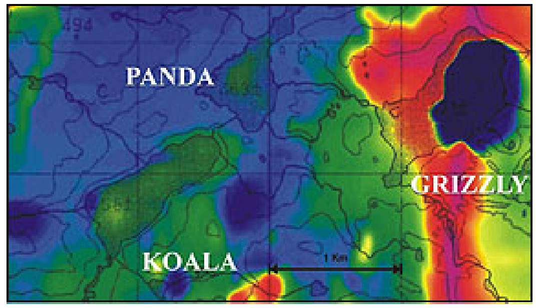




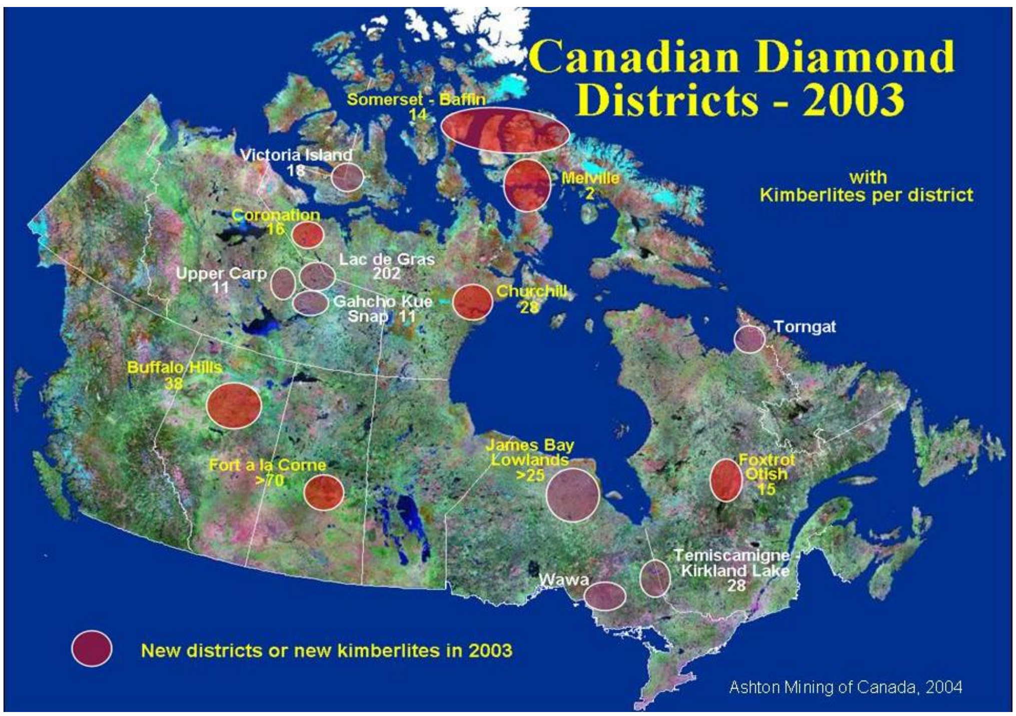
- Diamonds formed from carbon at very high pressures in the upper mantle
- Requires thick lithosphere to get the high pressures in a relatively cold region of the mantle.
- Eruption of kimberlites can bring the diamonds to the surface.
- Diamond exploration requires exploration for kimberlites.
- Magnetic exploration can help locate kimberlite pipes
- Since kimberlites are basic, must consider remant magnetization

(a) Kimberlites pipes can have **normal remnant** magnetization. Combined with the induced magnetization, this gives positive magnetic anomaly (in high magnetic latitudes)

(b) Pipes can also have **reversed remnant** magnetization, according to the age of eruption. Combined with the opposing induced magnetization, this gives a range of magnetic anomalies from negative to zero to weakly positive (in high magnetic latitudes)



Ekati Mine, NWT



From Ashton Mining of Canada

References

Alsdorf, D. and K.D. Nelson, *Geology*, **27**, 943-946, 1999.

Pilkington, M, W.F. Miles, G.M. Ross and W.R. Roest, Potential field signature of buried PreCambrian basement in the Western Canada Sedimentary Basin, *Canadian Journal of Earth Sciences*, **37**, 1453-1471, 2000.

Gibson, R.I., and P.S. Millegan, Geologic applications of gravity and magnetics: case histories, *Society of Exploration Geophysics*, 1998.