The Particle Size-Specific Nature of Magnetic Assemblages: Implications for Sediment Tracing & Palaeo-Environmental Reconstruction

Robert G Hatfield[1] and Maria T Cioppa[1]

[1]Department of Earth and Environmental Science, University of Windsor
hatfield@uwindsor.ca

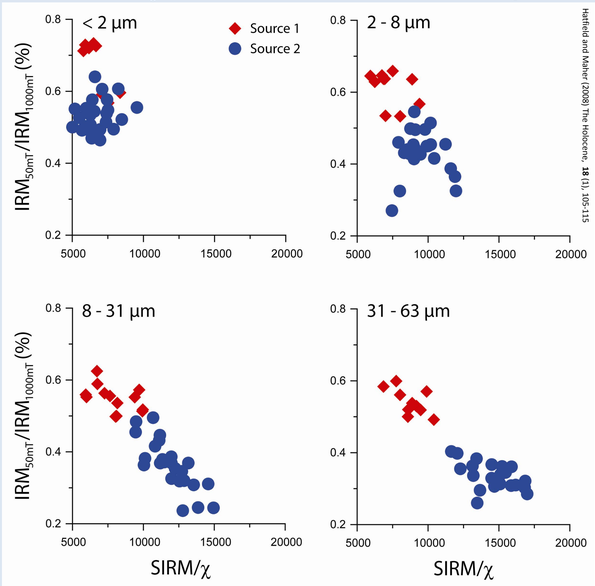
CBIE · BCEI
Canadian Bureau for International Education | Bureau canadien de l'éducation internationale

University of Windsor
thinking forward

1. Introduction:

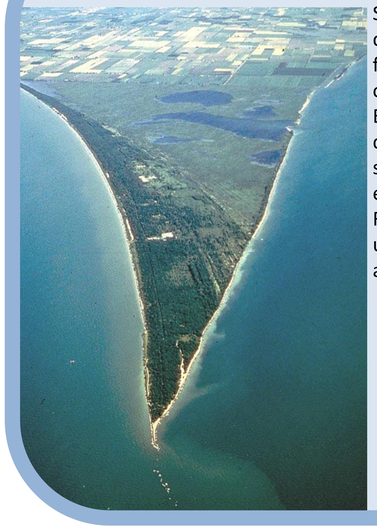
For tracing of sediments and reconstructions of past environmental conditions the properties of magnetic (and other) parameters are often assumed to be homogeneous between all particle size fractions. However, significant variation can be propagated due to pedogenic processes, biological processes, anthropogenic inputs or simply variation within the parent material (see below). This can result in complications for environmental reconstruction, especially within highly sorted environments (e.g. lakes, oceans, and coasts), as sink and source material often have different modal clastic sizes. Here we show that measurement of magnetic properties on a particle size specific basis can negate some of these issues and improve the resolving power of these techniques.

2. Example: Bassenthwaite Lake, UK

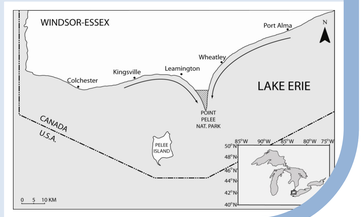


The 4 biplots show the magnetic properties of suspended sediments for two different rivers feeding Bassenthwaite Lake over 4 different particle size ranges. A range of different properties is displayed for each particle size. The suspended sediments are dominated by coarse clastic size ranges (> 31 µm) whereas the lake sediments are dominated by clays (< 2 µm). Bulk comparison of the two would indicate the lake sediments have lower SIRM/X and higher IRM_{50mT}/IRM_{1000mT} than any of the sources, resulting in misidentification of sources in this catchment.

3. Case Study: Point Pelee National Park

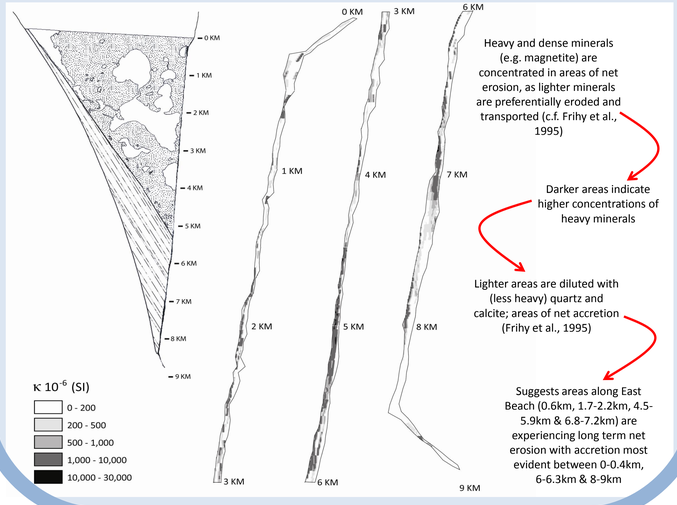


Sediment supply processes to PPNP are debated between alongshore transport from outside of the park and reworking of local sediments. Net erosion on Eastern Beaches threatens the UNESCO designated marsh complex and means sediment supply processes need evaluating for successful management. For effective management understanding of sediment dynamics and sources are key requirements.



4. Methodology:

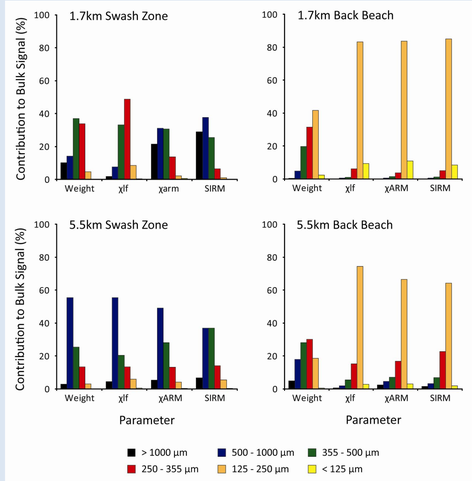
- In situ magnetic susceptibility measurements to map the distribution of magnetic minerals on East Beach, with a view to evaluating erosion intensity.
- Selection of 18 representative East Beach transects for more detailed measurement in the laboratory.
- Separation of swash zone and back beach sands into 6 particle size ranges.
- Comparison of East Beach, West Beach and interior samples on a particle size specific basis to try and evaluate the role of alongshore processes and landform reworking in sediment delivery and maintenance of East Beach.



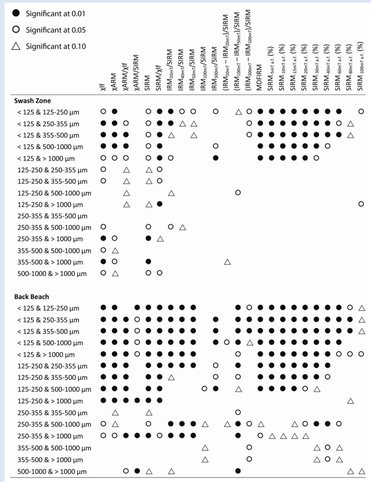
5. Particle Size Dependence:

Samples were firstly sieved into 6 particle size fractions. A) shows particle size distribution (weight) and relative contributions of each fraction to three magnetic parameters. Strong particle size dependence is evident, especially in the back beach sands e.g. at 5.5 km the 125 – 250 µm fraction only constitutes 19 % of the samples but carries 74 % of the magnetic susceptibility. B) quantifies the particle size dependence in the beach sands by the use of t-tests which show significant differences between different fractions for 24 magnetic parameters. These results show that for source unmixing, comparisons should only be attempted on a particle-size specific basis

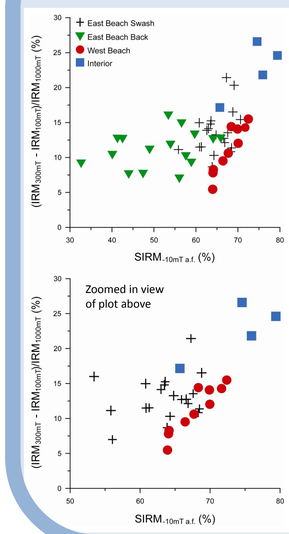
A)



B)



6. Unmixing



Using the 125 – 250 µm fraction (this fraction shows good discrimination between beaches and the interior and is representative of most of the bulk material in the swash zone, see table 5B) we can compare East Beach sands to both the interior and West Beach sands. These plots show that East Beach has different properties to both West Beach and the interior suggesting different sources provide material to these areas.

7. Conclusions

- Magnetic susceptibility is a valuable tool for mapping heavy mineral deposits & thus erosion intensity in beach environments
- Sands around PPNP are highly particle size dependent, thus source unmixing should only be attempted on a particle size specific basis
- Measurement of specific clastic size ranges can help increase the resolving power of fingerprinting studies
- Magnetic analyses discriminate well between the 4 areas of PPNP, despite the largely homogeneous geology in and around the park, making it a powerful fingerprinting tool.
- The magnetic data suggest material on each side of the point is sourced differently and that the interior provides little/no material to the beaches. This emphasises the importance of littoral processes in supplying material to at least one side of the national park. This is consistent with alongshore delivery processes.
- Good potential exists for the exploitation of particle size specific magnetic fingerprinting techniques in a range of different environments.