Raman spectroscopy in Geological Sciences

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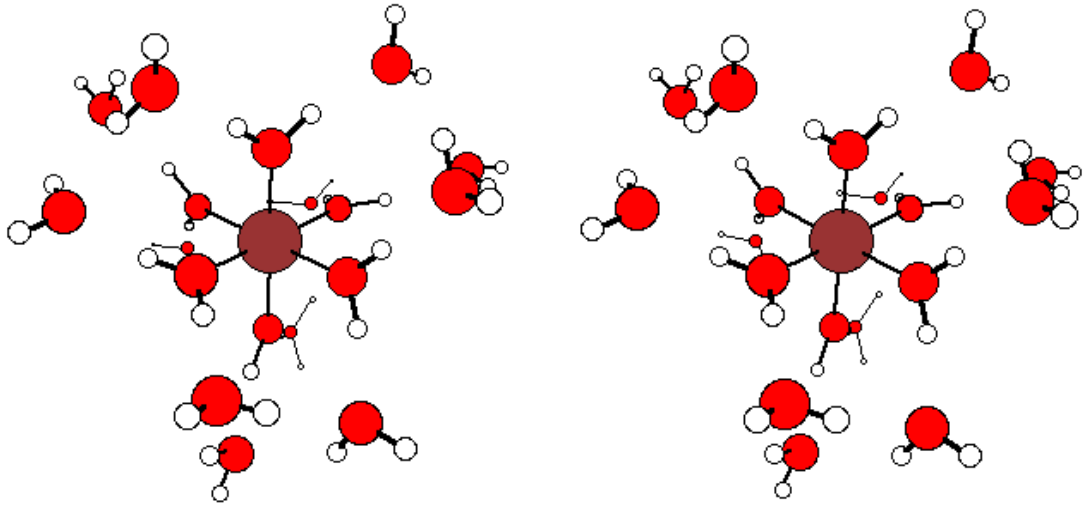
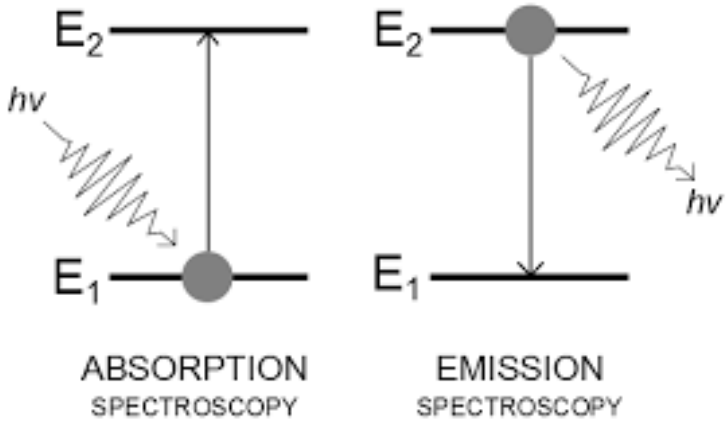
Vibrational spectroscopy

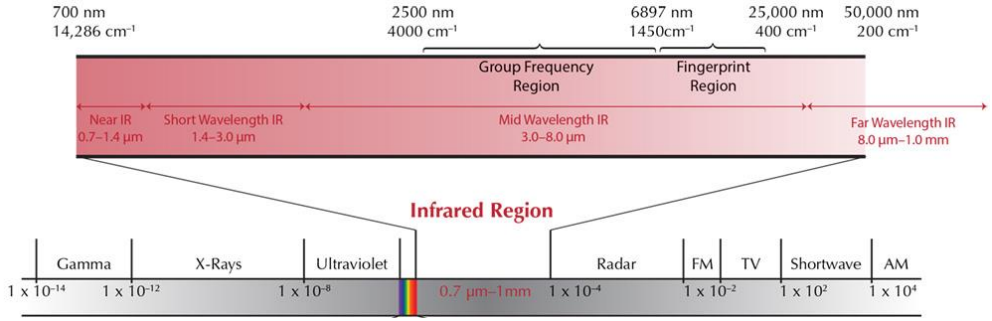


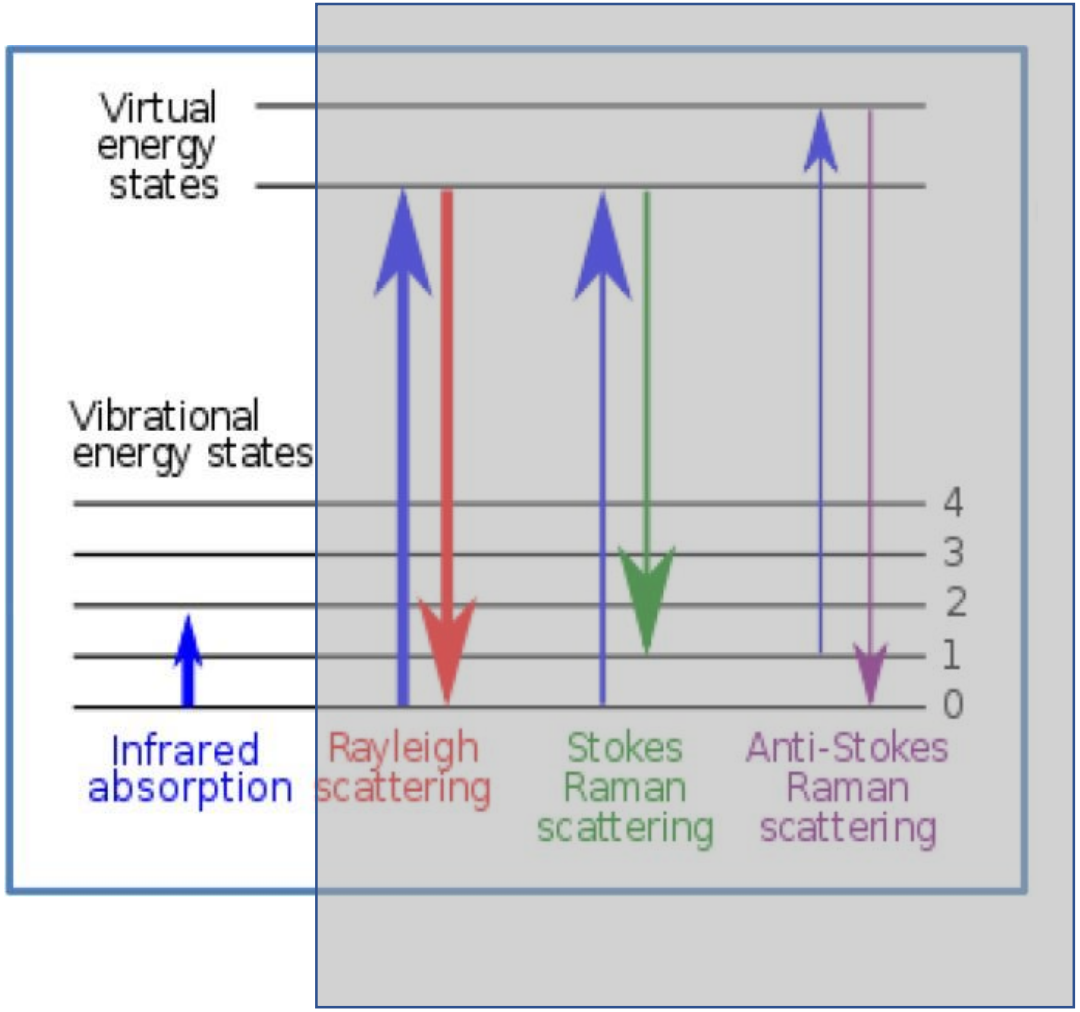
Molecular vibration occurs when atoms of a molecule changing their relative positions without changing the position of the molecular center of mass. In terms of the molecular geometry these vibrations amount to continuously changing bond lengths and bond angles.



When molecules react with an electromagnetic radiation with the same frequency of molecular vibration an energy transition occurs with a subsequent **release of energy** when the molecules come back to the ground state

Infrared Spectroscopy

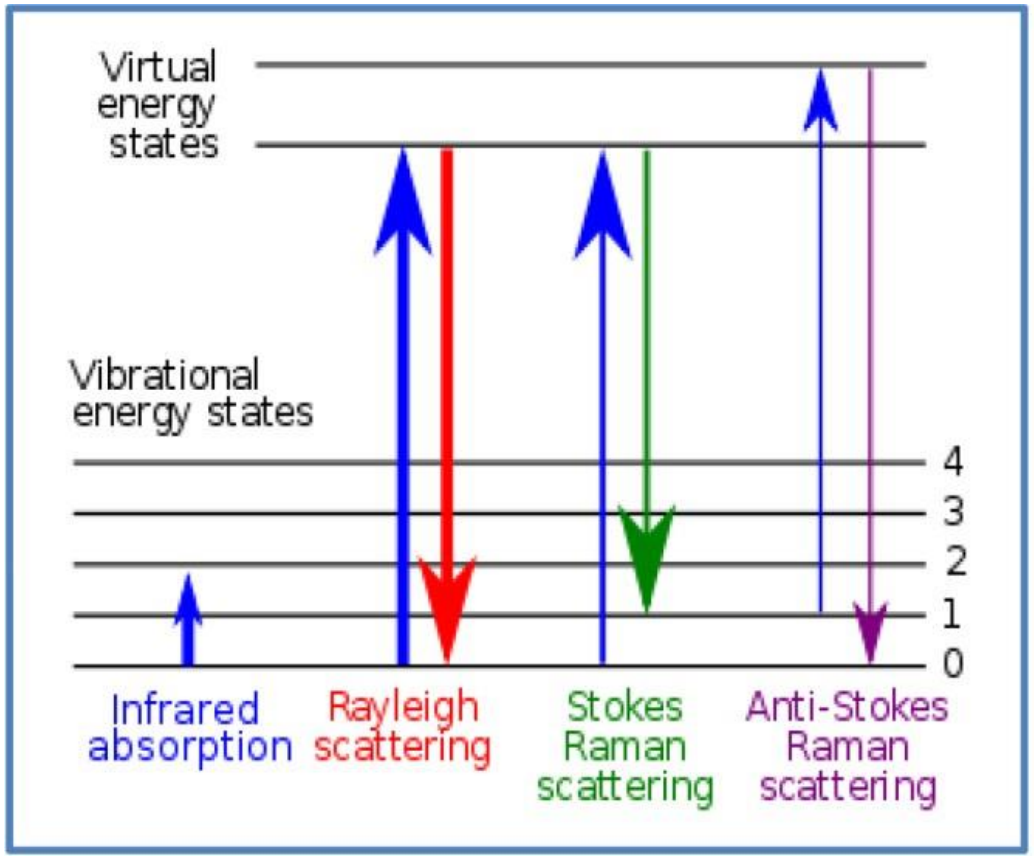


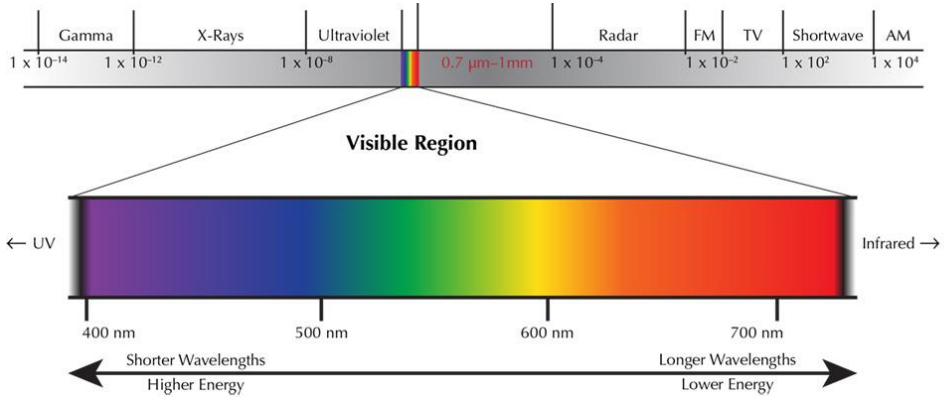


Infrared **frequency** are in the **same range** of most of the molecular vibration

Raman Spectroscopy

Sir C.V. Raman, *Nature*, 1928





Raman spectroscopy: - radiation at a certain frequency is scattered by the molecule with ***shifts*** in the wavelength of the incident beam.

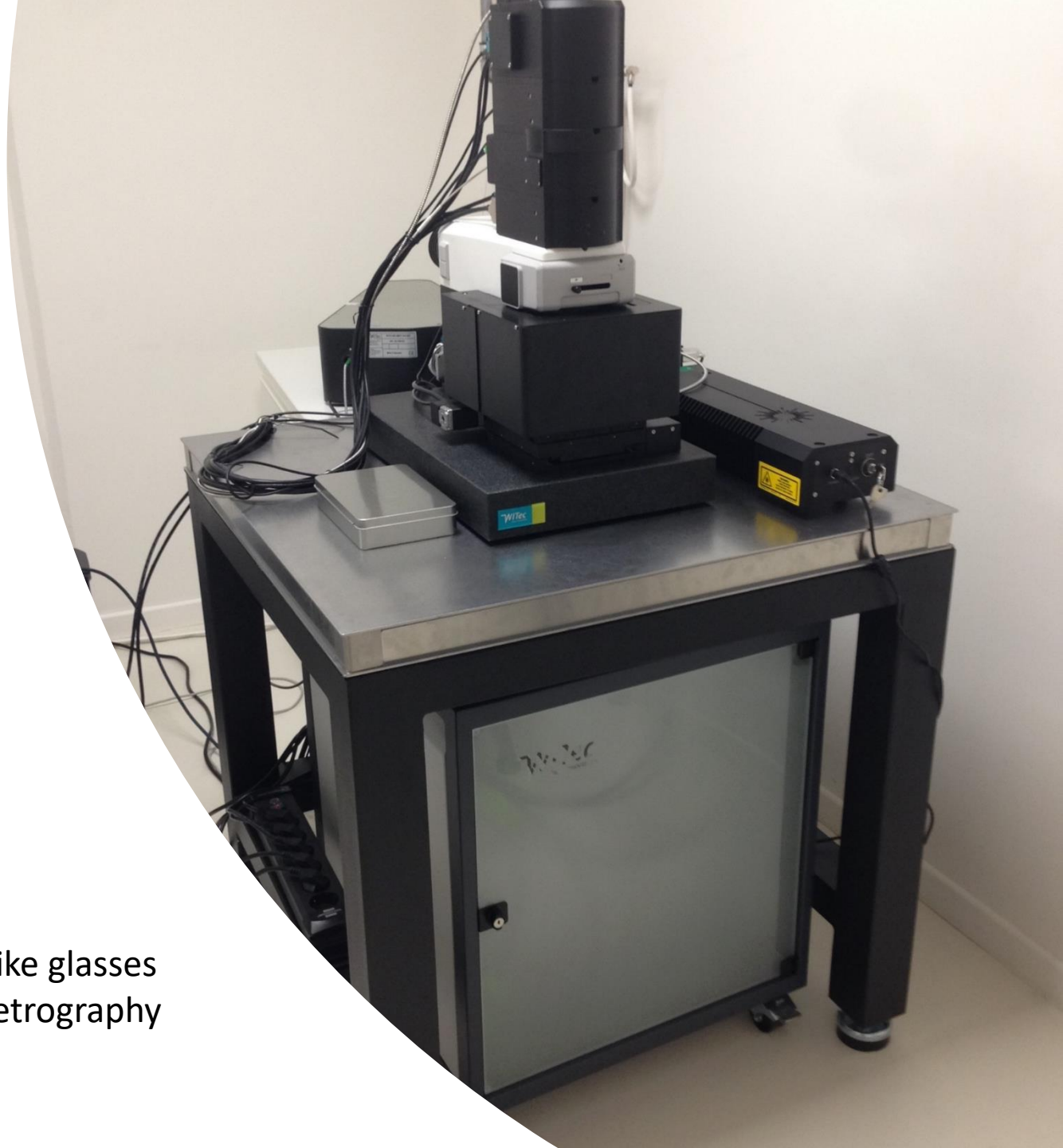
Elastic: collision between photon and molecule results in no change in energy

Inelastic: collision between photon and molecule results in a net change in energy

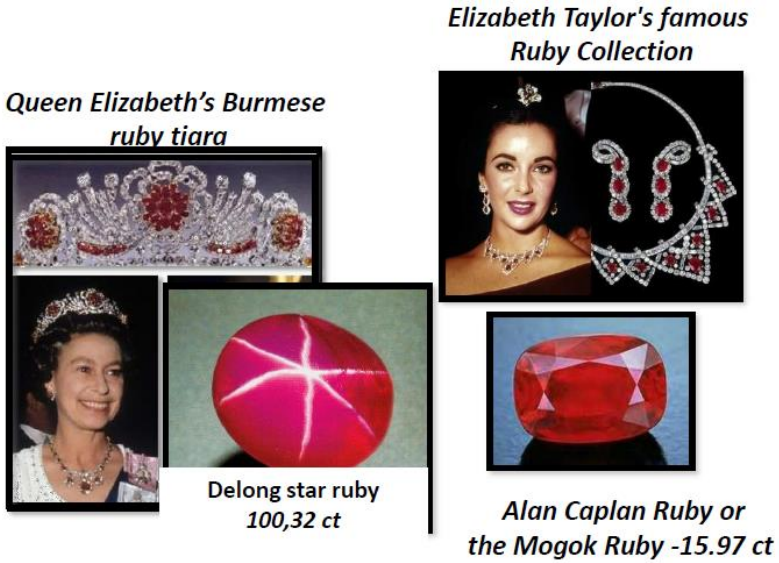
Raman spectroscopy is a suitable tool for Geological studies !

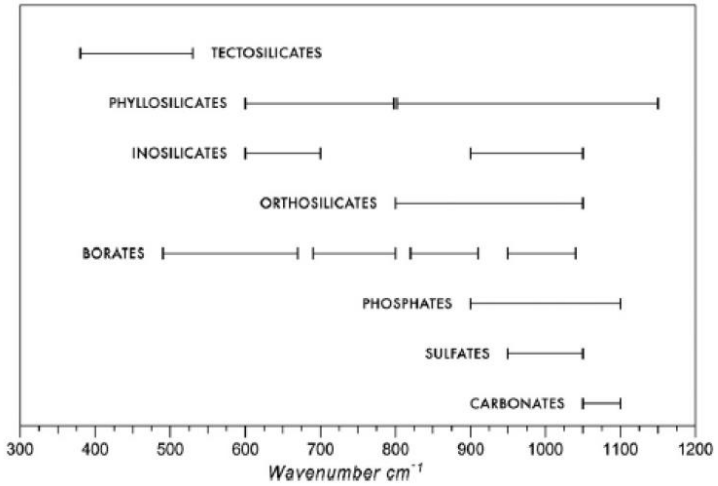
Advantages of Raman spectroscopy:

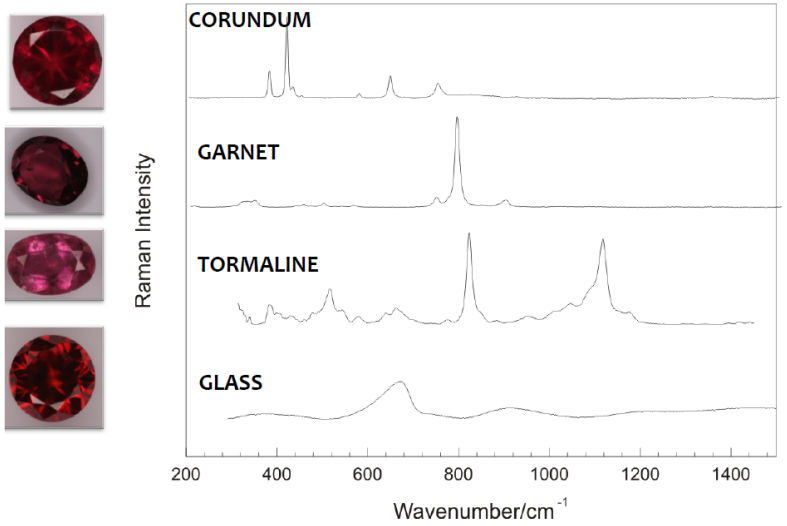
1) No sample preparation is needed
2) No Destructive
3) No invasive
4) High resolution
5) Short measurements



Idenfication of minerals and other amorphous phases like glasses and organic matter in **different fields of Geology** (e.g. petrography and mineralogy, volcanology, sedimentary geology)

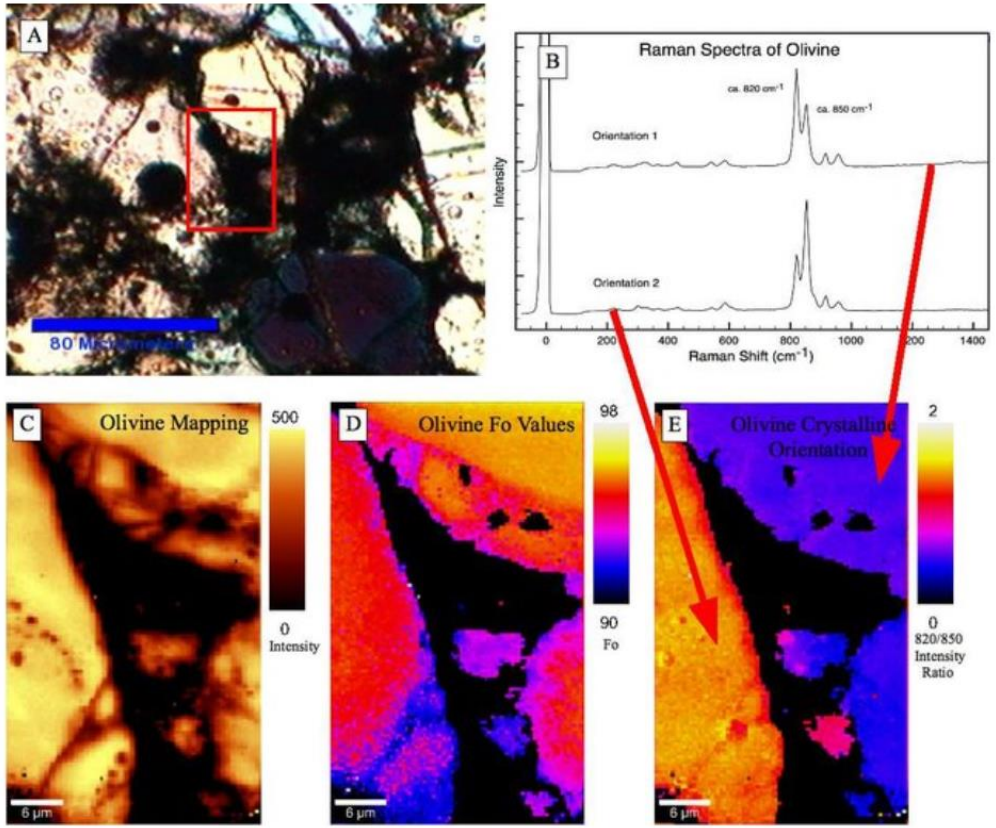


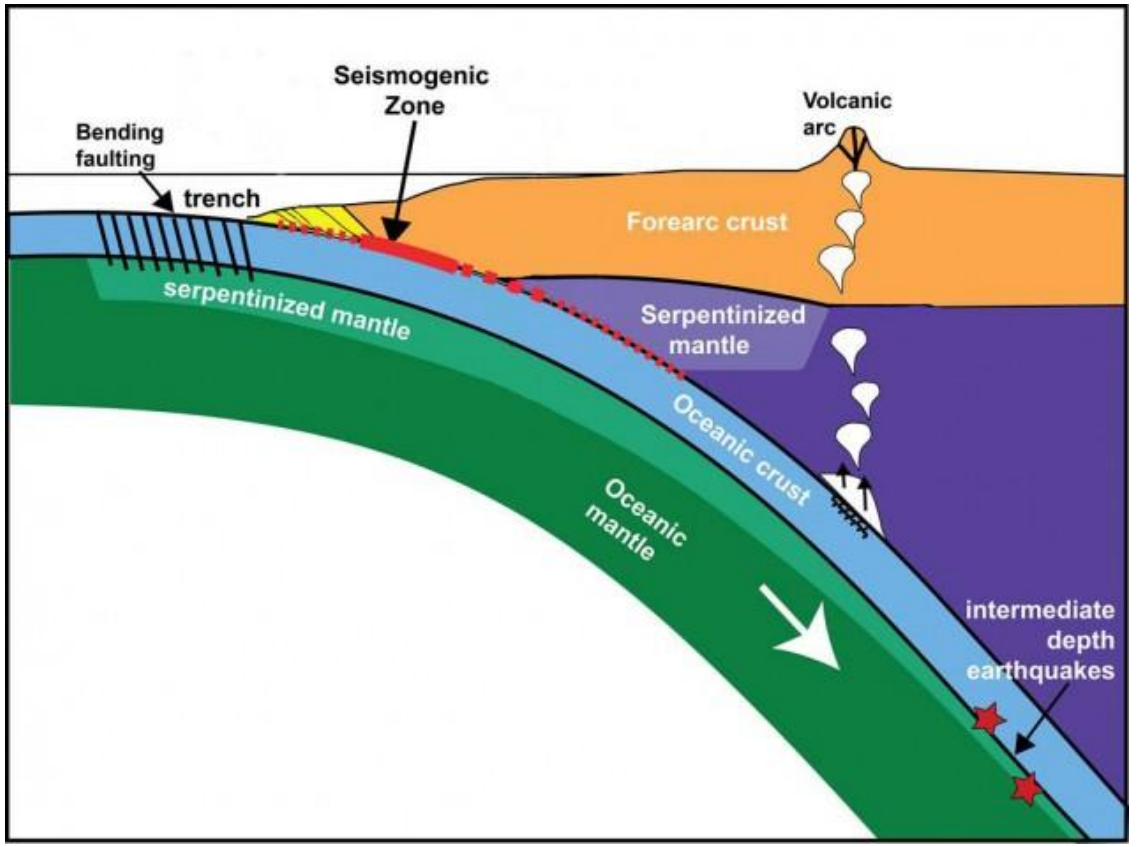




Identification of minerals

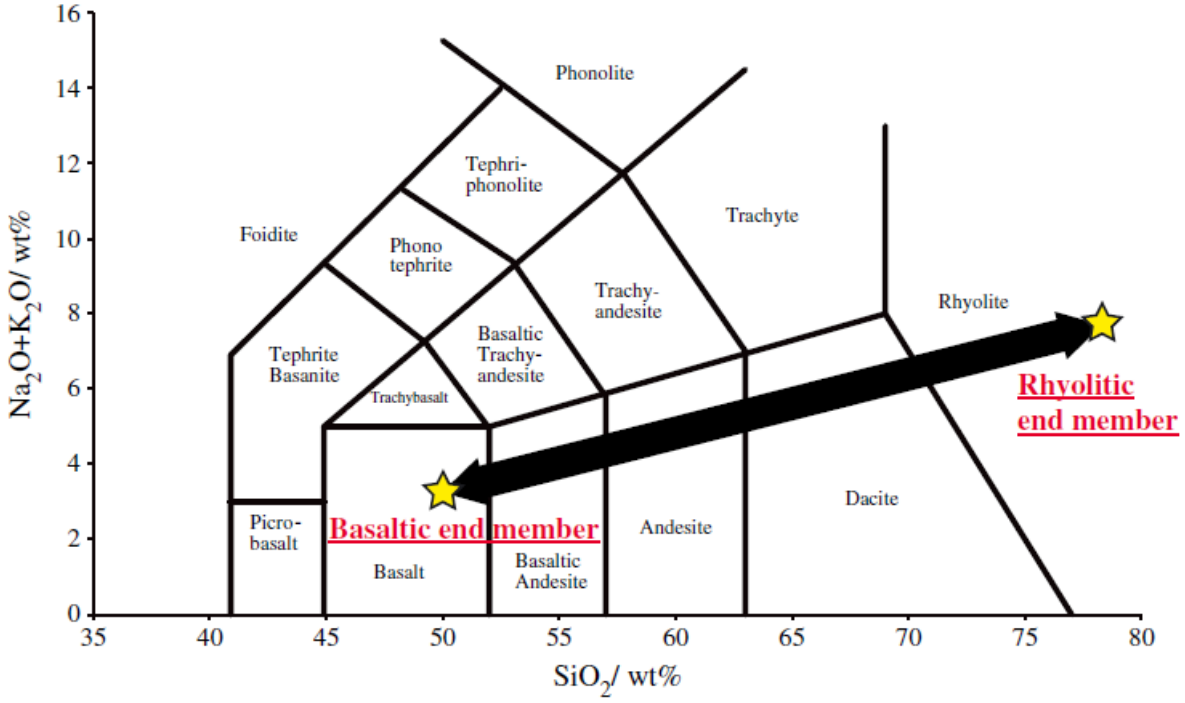
Gemmology



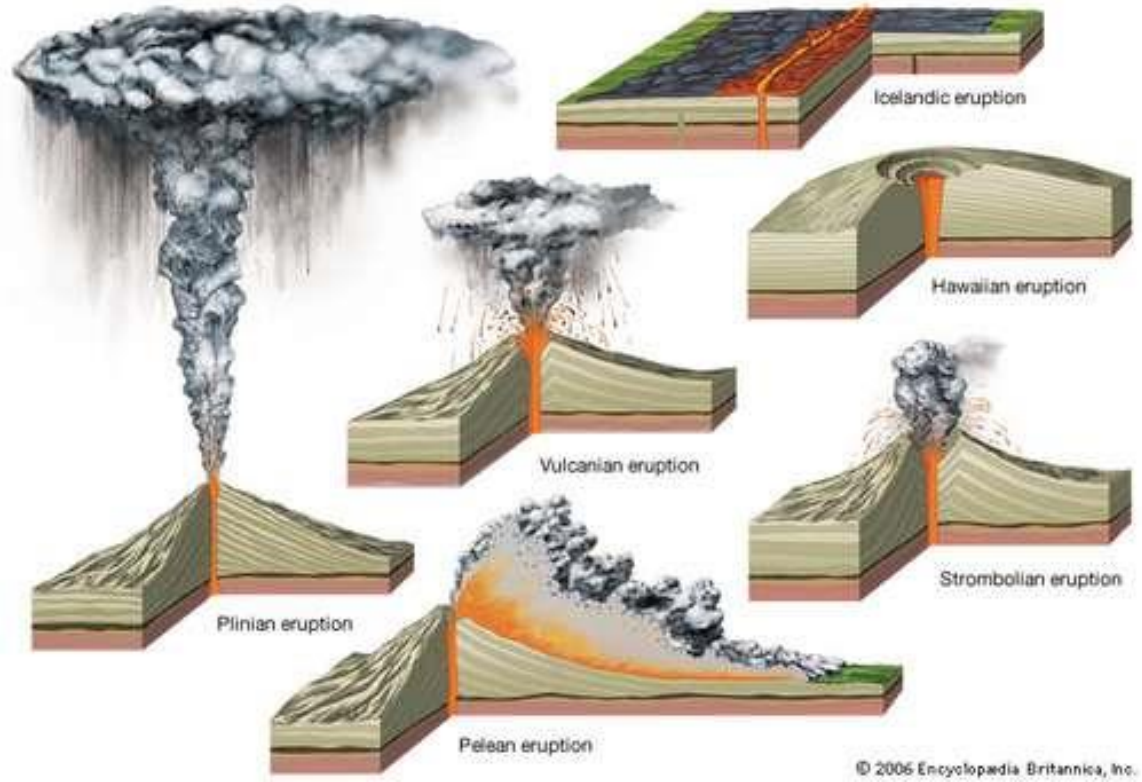


Identification of minerals

Petrography and Mineralogy

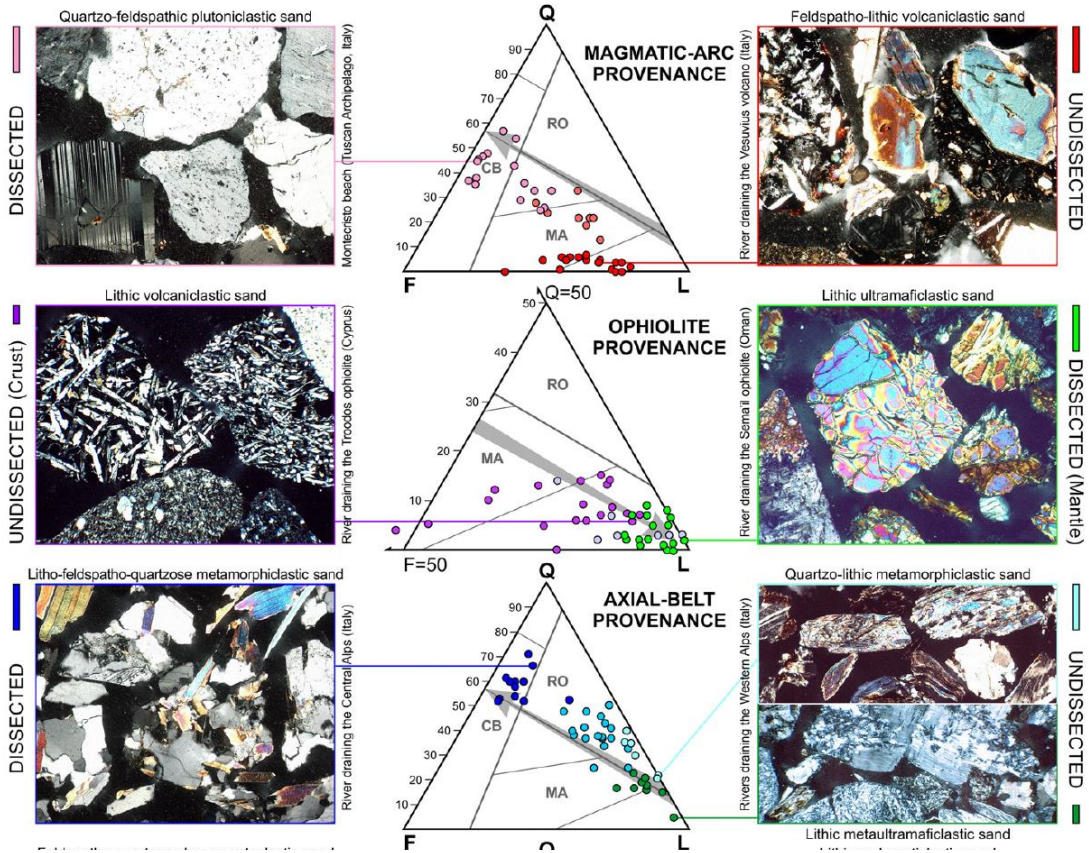


Di Genova et al., 2015

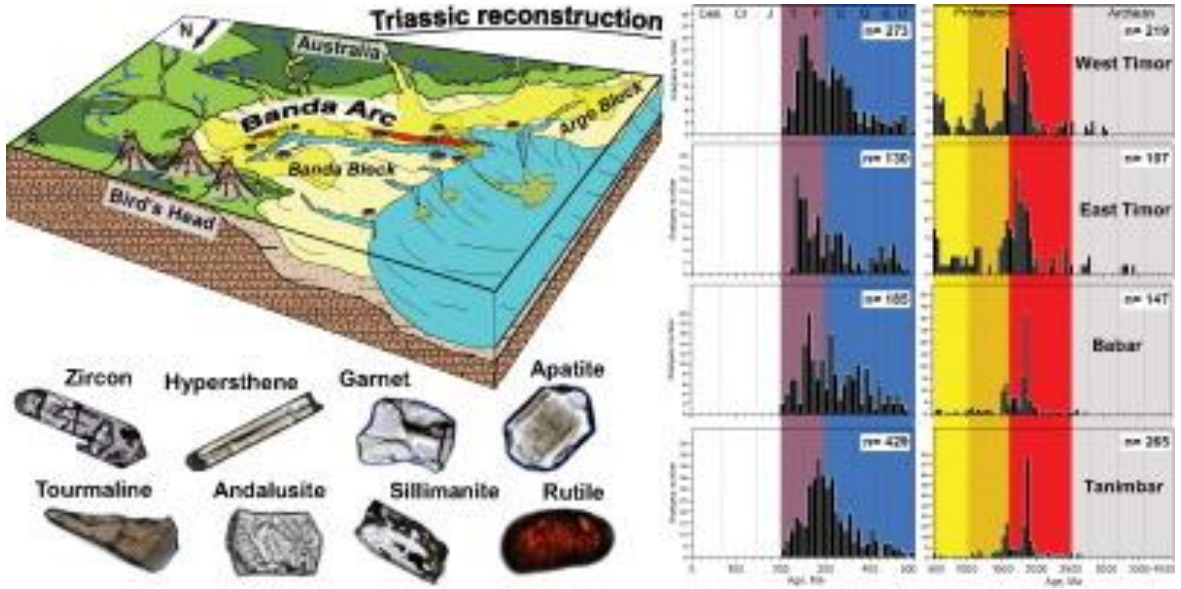


Identification of minerals and glasses

Volcanology

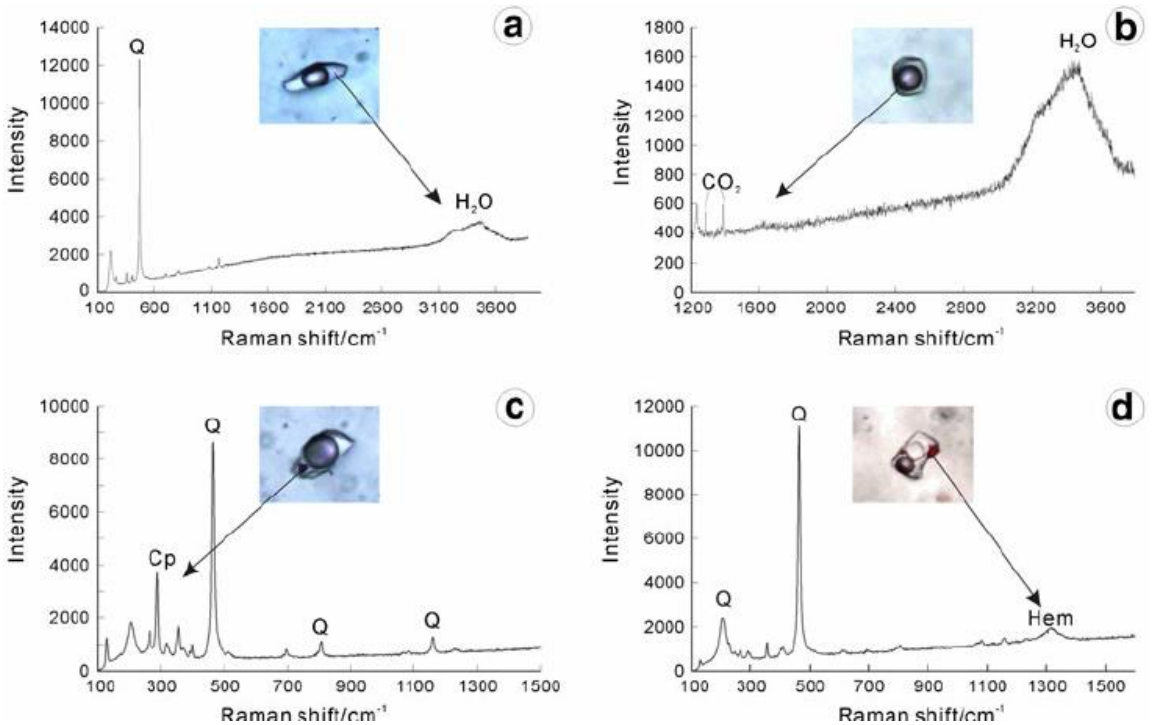


Garzanti et al., 2015

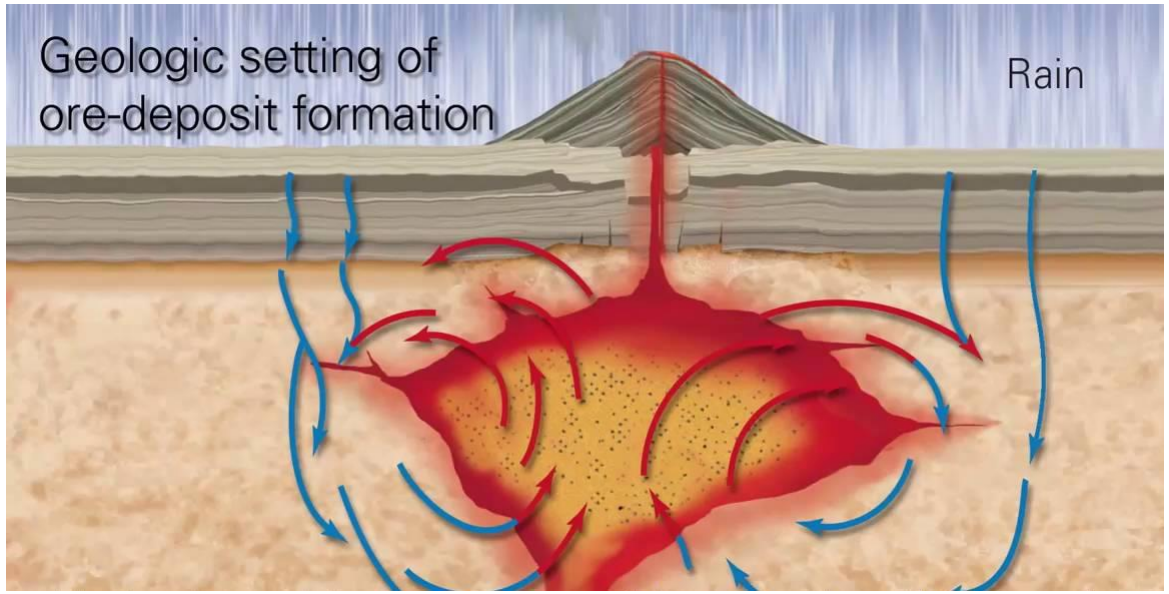


Identification of heavy minerals

Sedimentary Geology



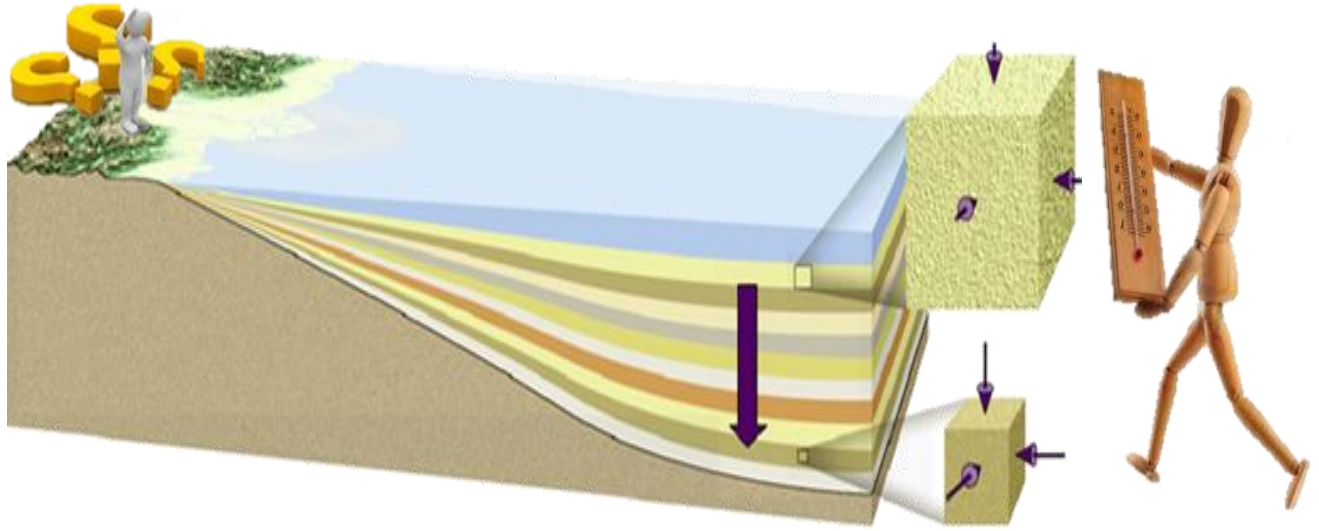
Frezzotti et al., 2010



Identification of Fluid Inclusions

Sedimentary Geology

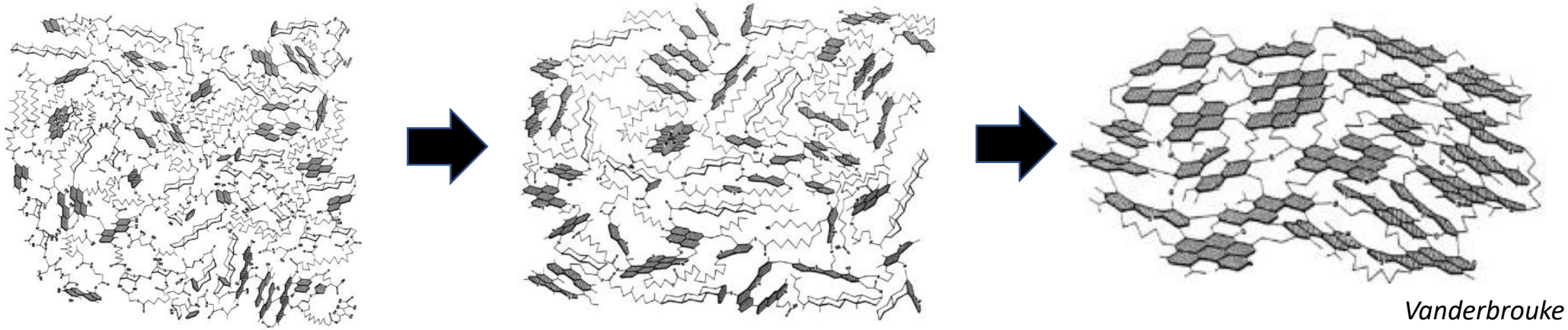
Thermal maturity of Sedimentary Basins



Key topic to:

1) Evaluate the burial history of sedimentary basins
2) Assess the HC generation/expulsion from source rocks

Progressive ordering of organic matter at increasing temperatures

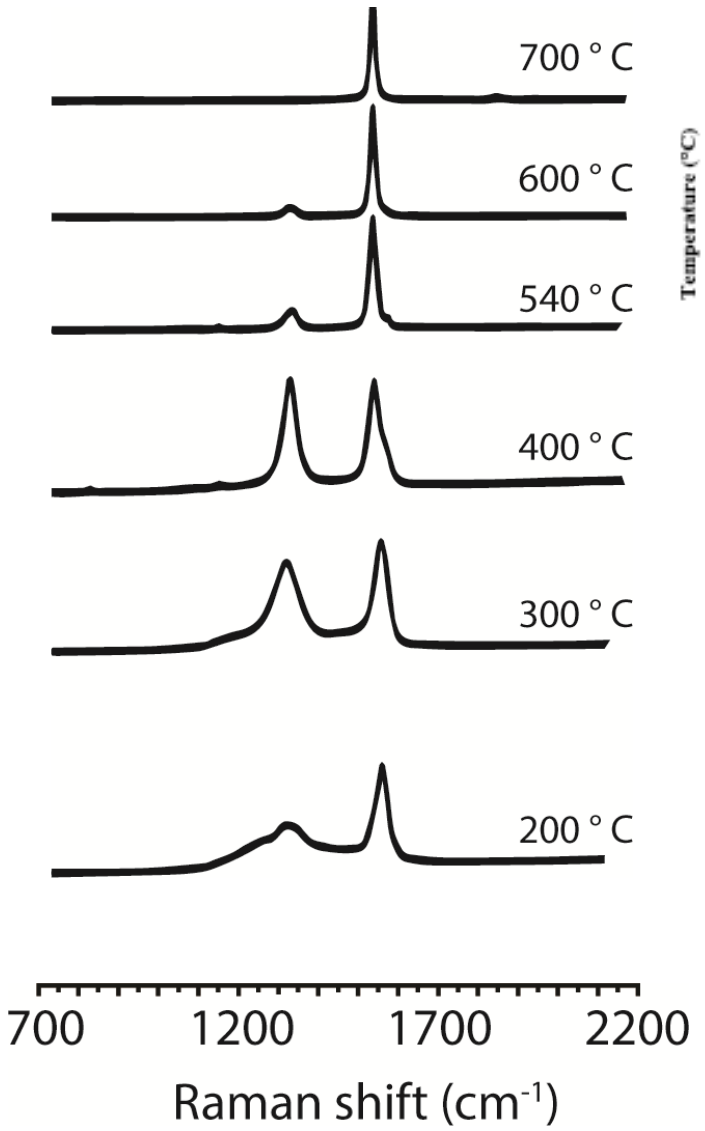


Vanderbrouke and Largeau, 2007

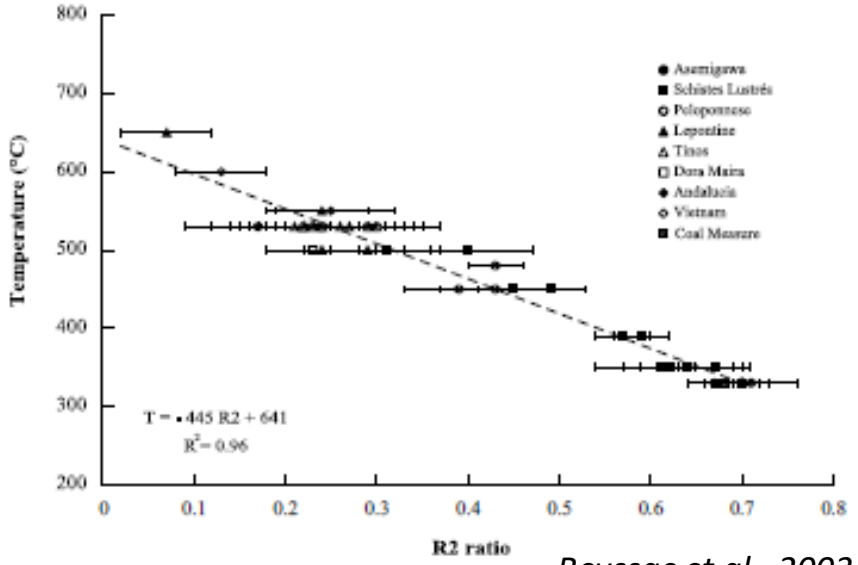
Metamorphism

Raman Spectroscopy on Organic Matter

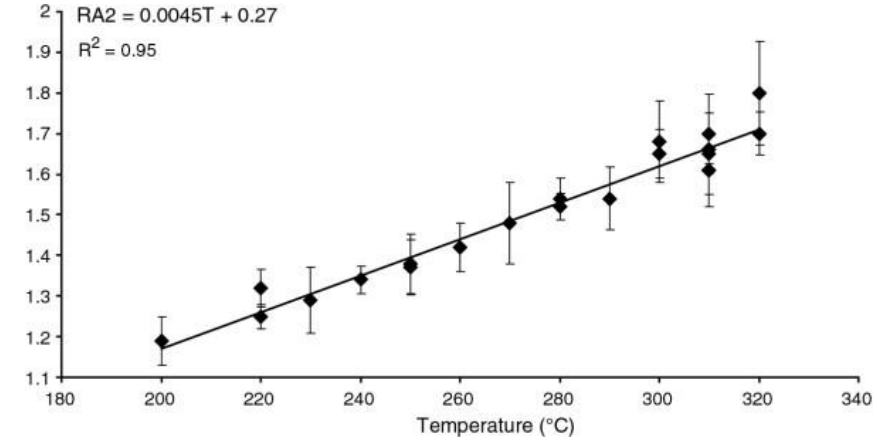
Can Raman spectroscopy on organic matter assess thermal maturity in diagenesis?



Beyssac and Lazzeri, 2013



Beyssac et al., 2003



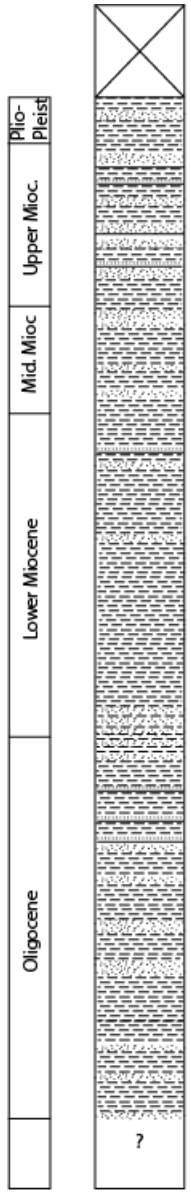
Lahfid et al., 2010

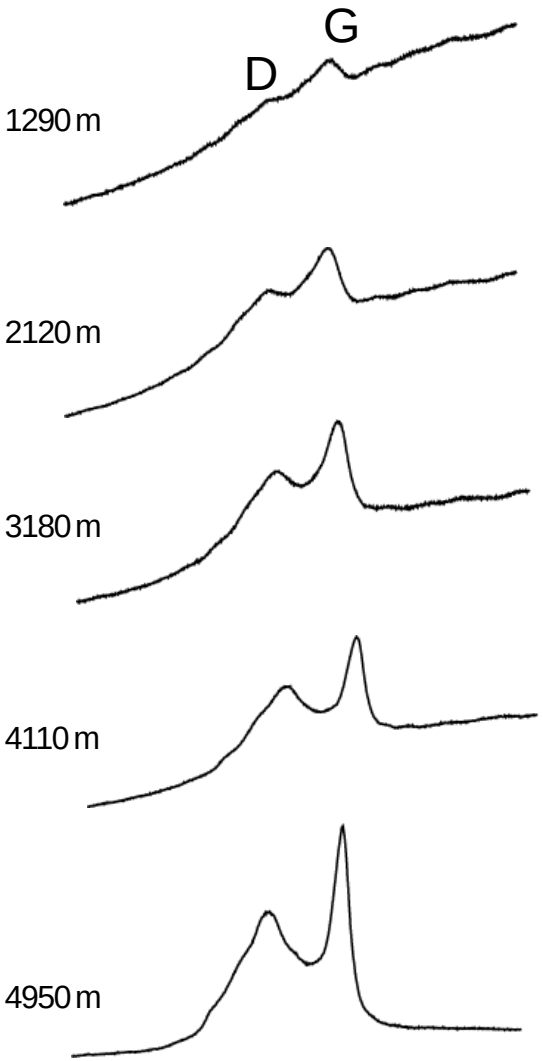
Diagenesis

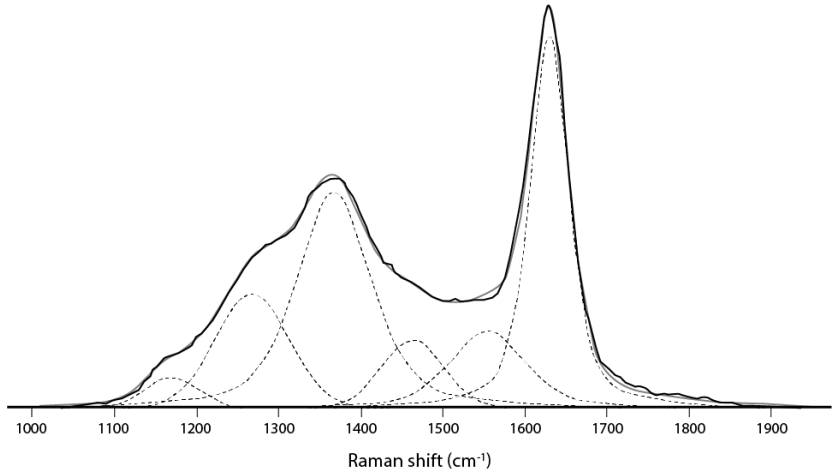
Raman Spectroscopy on Organic Matter

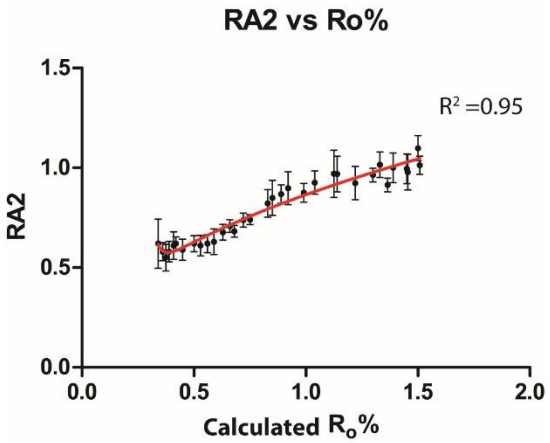
Problems in diagensis:

1) Organic matter hetereogeneity
2) Fluorescence of spectra
3) Band assignments









Schito et al., 2017

Raman Spectroscopy on Organic Matter

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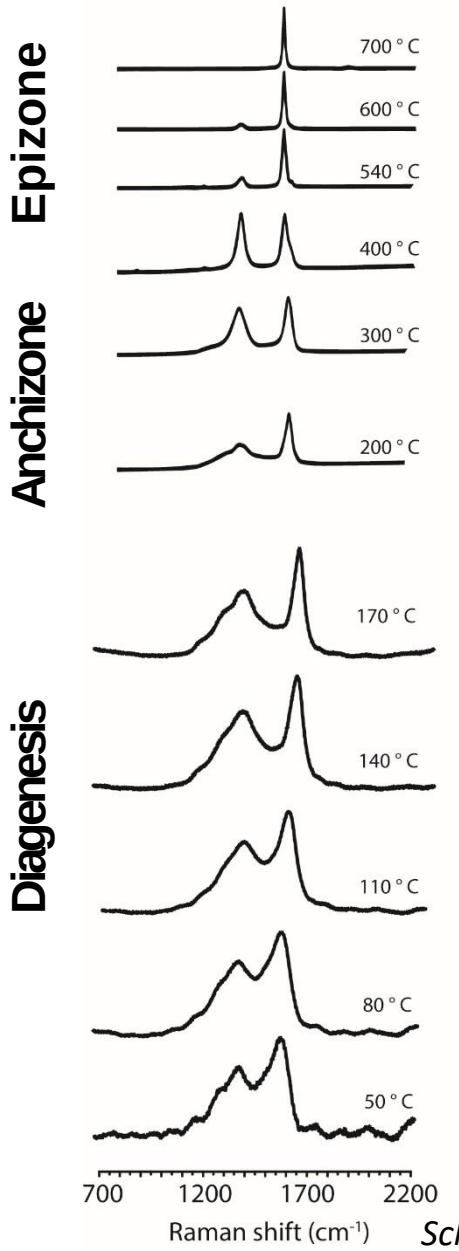
Diagenesis



Schito et al., 2017

Conclusions

- Raman spectroscopy is a powerful tool for geological investigations since allow a fast and accurate identification of minerals and other phases that are usually difficult to study with other techniques.

- Raman technologies are still fast developing today and we still don’t exactly known the level of accurancy it can reach in the next years

Thank you for the attention