2009-09: Geochemical reconnaissance of protoliths in high-grade metamorphic terrains

Areas of highly metamorphosed rocks pose significant challenges in exploration. In particular, it is often difficult to correctly identify protoliths (sedimentary vs igneous) of highly metamorphosed rocks. Yet, identification of the protoliths is crucial for the development of appropriate exploration models in these metamorphosed regions. Project 2009-09 aimed to develop a geochemical method applicable to metamorphic rocks for identifying protoliths.

A database containing a wide range of sedimentary and igneous rocks was compiled. The database was used as a reference for the automatic recognition of protoliths based on support vector machines. Two models were created: one using only major elements and another using Cr, Ni, Sr, Rb, Zr and Ba in addition to major elements. The models were constructed using slightly metamorphosed or unmetamorphosed rocks from the database, whose protoliths were well defined.

	Connu comme sédimentaire	Connu comme ignée
Identifié comme sédimentaire par le système	806	68
Identifié comme ignée par le système	64	790
% Correct	92.64%	91.01%

Rates of correct reclassification on a test group of slightly metamorphosed rocks with a known protolith, model using major elements + 6 trace elements. n = 1 728

The results of the reclassification using support vector machines are approximately 87 % for the model using only major elements and 92 % for the model containing Cr, Ni, Sr, Rb, Zr and Ba in addition. However, recognition success varies with rock type and type of alteration. Success rates are excellent for slightly altered igneous rocks, mudstones and chemical sedimentary rocks (limestones, dolomites, etc.). Success rates were lower for altered felsic and intermediate igneous rocks, and sandstones. Tests on the metamorphosed rocks with known protoliths from the reference database indicate a rate of about 85 % correct reclassification, confirming the applicability of the models to metamorphic rocks.

The method was tested using several case studies of mineralised and unmineralised metamorphic rocks. The Winston Lake and Montauban deposits confirmed that the potassic and aluminous alteration of igneous rocks makes their signatures similar to sedimentary rocks. However, examination of several samples from altered igneous rocks shows a spread between igneous and sedimentary response, which is different from actual sedimentary rocks. The result suggests that if the recognition is perhaps difficult on an individual sample level, the interpretation of a set of samples is conclusive. A number of case studies from other high-grade metamorphic terrains confirms the method to be robust up to migmatisation grade.

The method is implemented in the CONSOREM software for lithogeochemical data processing (project 2009-01).

CONSOREM
Consortium de recherche en exploration minérale

Project 2009-09: Summary	
Objectives	• To develop a geochemical identification method for protoliths (sedimentary vs igneous) in metamorphic rocks.
Results	• 2 mathematical models for protolith identification: one using major elements and another using major elements + Rb-Sr-Zr-Cr-Ni-Ba. • Statistical validation of the identification models and testing of models using case studies to show their efficacy (correct in 90 % of cases) and their limits in some cases (e.g.: potassic and aluminous alteration of felsic rocks).
Innovations	• Geochemical recognition tool for protoliths (sedimentary vs igneous) of metamorphic rocks.