Preliminary interpretations and implications for tectonics and deep geology of the Northern Cordillera using new magnetotelluric data.

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Introduction

The Slave-Northern Cordillera Lithospheric Evolution (SNORCLE) Trancset addresses LITHOPROBE's theme of crustal evolution through an integrated program of geological and geophysical studies across this geologically diverse region and through four billion years of Earth's history. The application of the magnetotelluric (MT) method to the study of the northern Cordillera has three principal objectives. The first concerns characterization of the regional conductivity properties of the northern Cordillera in relation to the major tectonic units. The second thrust involves upper mantle features: determination of the depth extent and internal variation within the lithosphere beneath the Cordillera the fate of the vast amount of pacific lithosphere overridden by North America during the past. The third specific goal is determination of the subsurface geometry and character of the Tintina strike-slip fault zone for comparison with the reflection data and a better understanding of reasons for conductivity enhancement at faults.

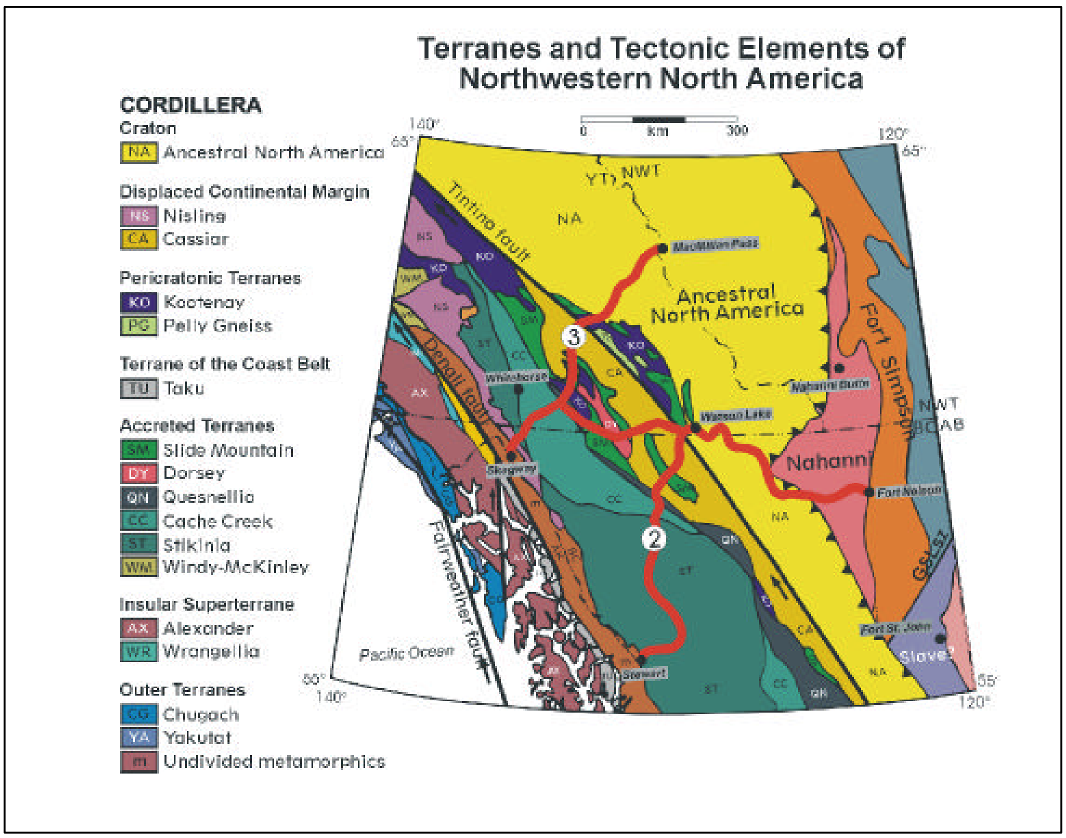

Figure 1. Snorcle MT trancset (red line) on a map of the terranes and tectonic elements of northwestern North America. Faults are heavy dark lines.

Geological setting

The northern Cordillera consists of a great variety of rock types ranging in age from early Proterozoic to recent and representing different tectonic episodes, among them: epicratonic basins, subsiding shelves, foreland basins, island arcs and deep ocean basins. These rocks have been submitted to different episodes of compressional and extensional deformation, transcurrent faulting, metamorphism and plutonism. This complex geological record has been described in terms of interactions of several terranes with each other and with the margin of ancestral North America. The ancestral North America is a passive continental margin assemblage, where strata had been deposited since Early Proterozoic to Lower Cretaceous, and reflect a broad range of depositional environments. The Cassiar Terrane is considered to be a portion of the North American miogeocline that was displaced dextrally along the Tintina-Northern Rocky Mountain system. To the west of the Tintina Fault, the crust is comprised of several terranes that were accreted to the continental margin. The nature and evolution of the terranes and its boundaries are complex and still controversial (e.g., Gabrielse and Yorath, 1992; Gordey and Makepeace, 1999).

Magnetotelluric method

The magnetotelluric method uses the fluctuations of the natural electromagnetic field at the Earth's surface to study the lateral and vertical variation of the electrical conductivity of the Earth's interior. The physical parameter being sensed is the electrical conductivity, which varies over a range of eight orders of magnitude. Most rock-forming minerals in the crust have very low conductivity and they are classed as insulators. The enhancement in electrical conductivity of the Earth's crust is due to ionic conduction and/or electronic conduction. The first one occurs when ions are free to move through fluids (i.e. water, partial melt) and the second one occurs when electrons move through electronically-conductive solids (i.e. graphite, sulphides, iron oxide's). Moreover, the bulk electrical conductivity depends not only on the amount of ionic fluids and/or electronic conductors, but also on their geometric distribution within the host rock. These are useful tracers of tectonic and geodynamic processes that are difficult or impossible to sense remotely by other techniques. Penetration to all depths is assured by the skin depth phenomenon. The depth of penetration of an electromagnetic wave into the Earth depends onto the Earth's conductivity and the periodicity of the electromagnetic wave. The analysis of different periods allows us to obtain information at different depths, and to determine the dimensionality of the geological structures (2D or 3D), strike direction and its depth dependence. The interested reader is referred to Jones (1992) in which the fundamentals and applications of the MT method is explained with more detail.

The fieldwork began in August 1999 and finished at the end of October 1999. In total more than two hundred MT sites (AMT, broad band and long period) have been acquired. The data are presented as a pseudosection of the phases determinant (figure 2) of the broad band data, that is invariant under rotation, and shows the main regional structures. Phases values higher than 45 degrees are associated to the presence of conductive structures, and phases below 45 degrees correspond with the response of more resistive structures. The main characteristic of the data is the presence of a resistive upper crust (low periods) in relationship with a more conductive lower crust (high periods). Moreover, some vertical conductive structures can be observed at lower periods that could be related to the presence of fault systems.

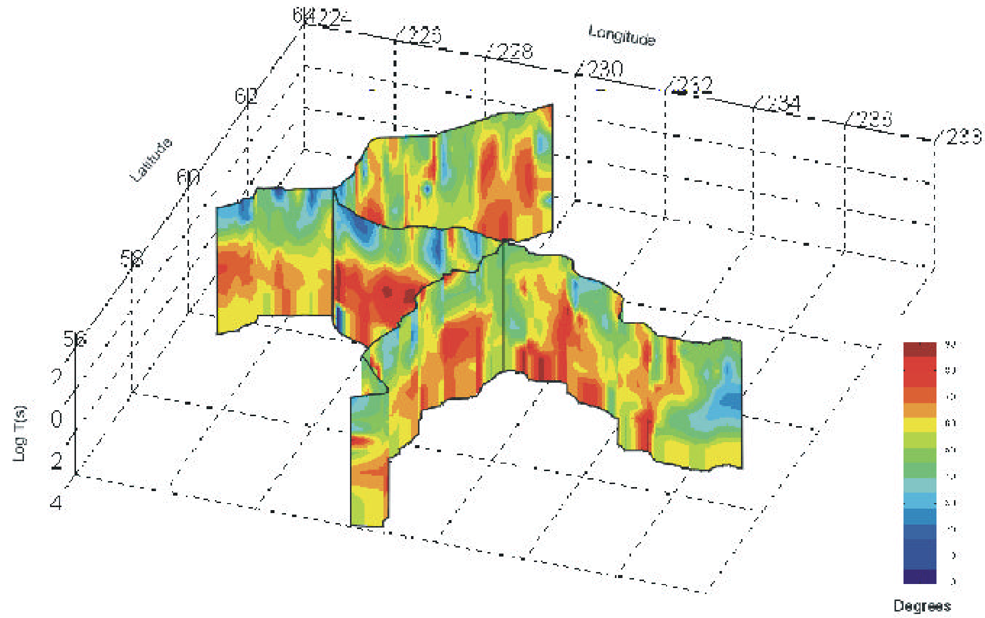

Figure 2. Pseudosection of the phases determinant for the broad band MT data.

Preliminary results

Here we present the preliminary results obtained across the Tintina fault at Ross River. The Tintina Fault is a major transcurrent fault along which an estimated 450 km or more of Cretateous-tertiary dextral displacement. The period range of the data used is 0.01-8000 s, which allows us to image the earth structure from near surface (hundred meters depth) to deep into the mantle (> 50 km). 2D Objective modeling of the apparent resistivity and phases for the two principal electromagnetic directions, parallel and perpendicular to the fault was done using the algorithm of Mackie and Rodi (1996) (figure 3). The main results are the presence of several subvertical contacts both near surface (e.g. Tintina Fault) and deep in the crust (e.g. St. Cyr Fault). The trace in surface of the Tintina Fault coincides with an important lateral contrast in the electrical properties up to 4-5 km deep. To the southeast, there is another vertical contact that correlates with the surface trace of the St. Cyr Fault. This structure penetrates deep into the crusto, although the bottom of this structure is not well constrained. To the northwest a high resistive structure is imaged up to 20 km deep. The analysis and decomposition of the whole magnetotelluric data set will be the preceding step to obtaining an electrical resistivity distribution of the subsurface structures. The correlation between the electrical structures with other geological and geophysical parameters will be one of the main objectives for future research activities.

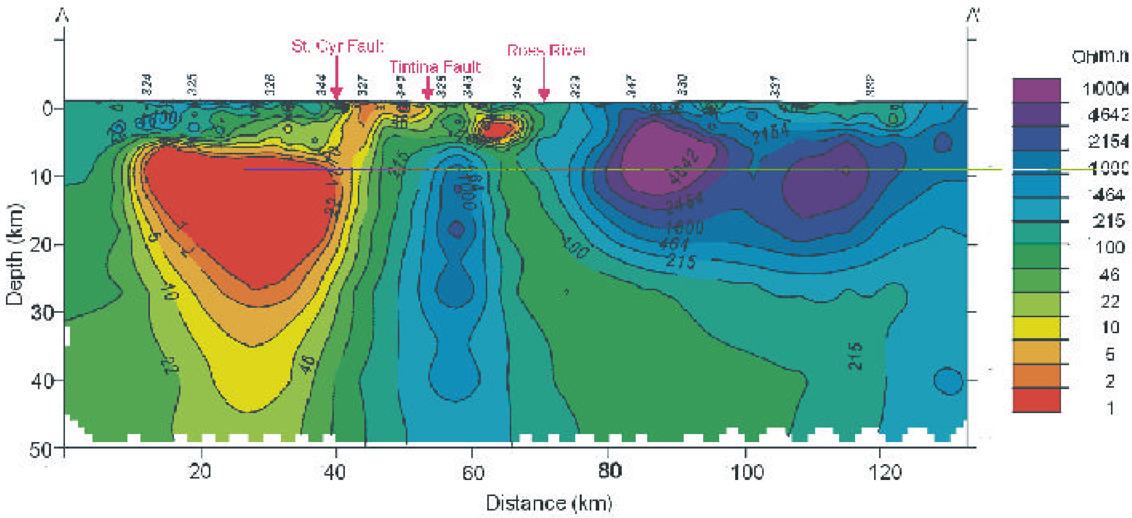

Figure 3. 2D model across the Tintina Fault at Ross River.

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