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A study of the lake sediment geochemistry of the Melville Peninsula using multivariate methods: Applications for predictive geological mapping

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ABSTRACT

The effectiveness of predictive geological mapping was tested using re-analyzed lake sediment geochemical data from lakes across the Melville Peninsula in Nunavut, Canada. The treatment of lake sediment geochemical data within the compositional framework of logratio analysis and the corresponding use of principal component analysis, analysis of variance, linear discriminant analysis and spatial analysis with ordinary kriging provide an informative and quantitative manner for lithologic mapping. Principal component analysis provides useful information on the multi-element associations based on the contrast of rock types in the area. Supracrustal sedimentary rocks have a multi-element character that is distinctive from rocks derived from granitoid and gneissic rocks. The analysis of variance provides details on which elements are the best discriminators for differentiating between the rock types represented by the lake sediment geochemistry and the spatial analysis provides insight into the direction and spatial continuity of the elements associated with specific map units. Linear discriminant analysis provides a basis for distinguishing between the different map units and provides a method of validating the predictive capability of mapping the underlying map units based on the lake sediment geochemistry. The application of multivariate statistical methods on lake sediment geochemical data provides the basis for establishing an objective approach for discovering and classifying geochemical processes from which existing geological maps can be tested and validated and new geological maps can be made in areas where sufficient geological information is lacking.

1. Introduction

Government geological surveys and mineral exploration companies collect large amounts of geochemical data that are used in search for mineral commodities or for environmental studies. These surveys consist of many thousands of samples (observations) with as many as 50 elements determined for each. Evaluating these large sets of data can be a challenge for recognizing the value and potential that the data have in offering insight into geological processes (Grunsky, 2010). A limited investigation of the lake sediment geochemistry of the Melville Peninsula (Grunsky et al., 2012), revealed that lake sediment geochemistry has the potential to provide useful information about the underlying geology of the area.

In this study, the evaluation of the Melville Lake sediment geochemical data, we ask the question; what can we learn from the lake sediment geochemistry in terms of its representation of the regional geology and the ability to predict features of the geology not readily recognized by other means? The purpose of this contribution is to highlight the value of multi-element geochemical data as an aid to regional geological mapping through the collection and evaluation of regional geochemical survey data in the Melville Peninsula area of Nunavut (Fig. 1).

1.1. Bedrock geology

The tectonic setting and geology of the Melville Peninsula are described by Corrigan et al. (2011) and the regional geology is shown in Fig. 2. The map units are listed in Table 1. The Melville Peninsula (Fig. 1) is located in the north-central Rae Craton of the western Churchill Province (wCP). The tectonic setting of the wCP is a collage of polymetamorphic and polydeformed Archean cratons unconformably overlain by Paleoproterozoic supracrustal sequences and intruded by various intra-plate Proterozoic magmatic suites. It is characterized by widespread tectonothermal reactivation related to the assembly of the supercontinent Nuna during the interval 1.95–1.80 Ga (Corrigan et al., 2011). The geology is comprised of four contrasting first order lithotectonic subdivisions (Fig. 2) although only the Prince Albert Terrane and the Penrhyn Group sediments are shown in Fig. 2: The Prince Albert terrane is comprised of Meso- to Neoarchean crust with inliers of Prince Albert Gp. (PAG) volcano-sedimentary rocks, which was further reworked to the southeast along with the Paleoproterozoic Penrhyn Group cover sequence. Additional descriptions of the geology and tectonic setting of the area can be found in Machado et al. (2011, 2012).

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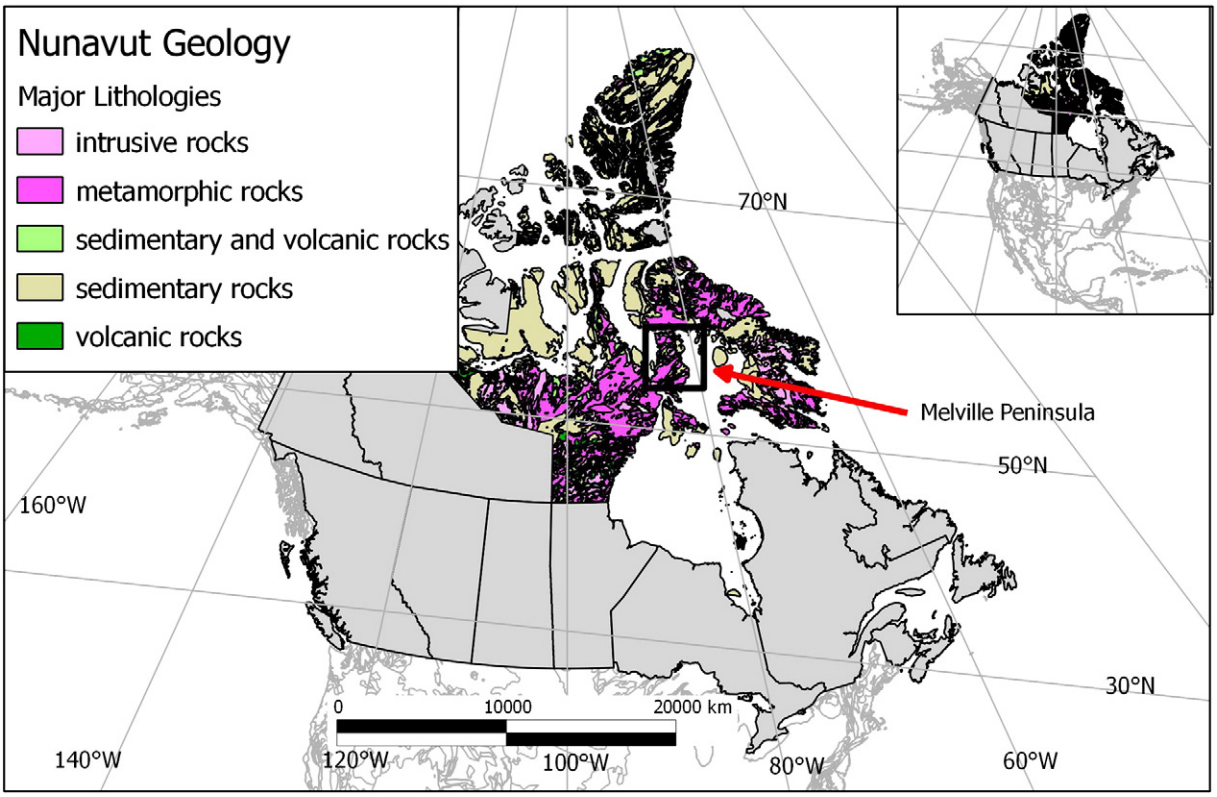

Fig. 1. Regional geology of the Melville Peninsula.

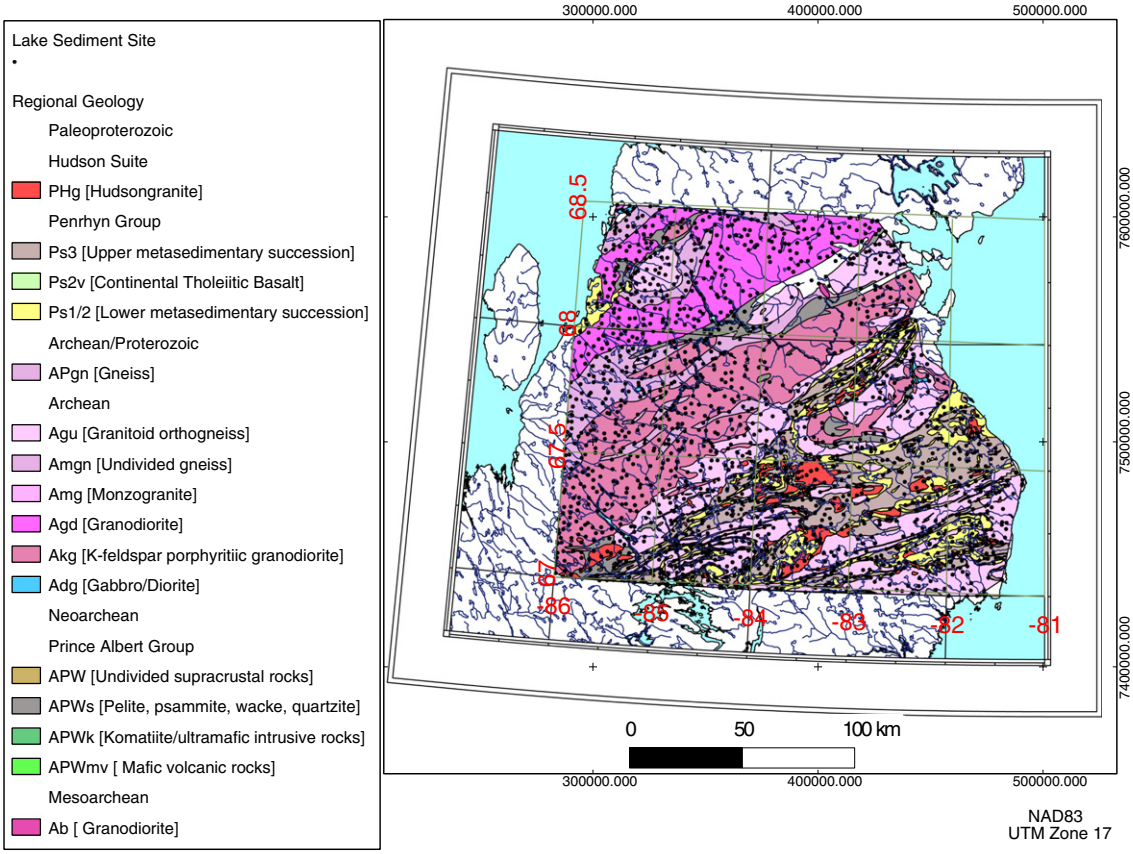

Fig. 2. Geology, mineral occurrences and lake sediment sample sites of the Melville Peninsula. Latitude/Longitude graticules shown in red. UTM coordinate grid shown in black.