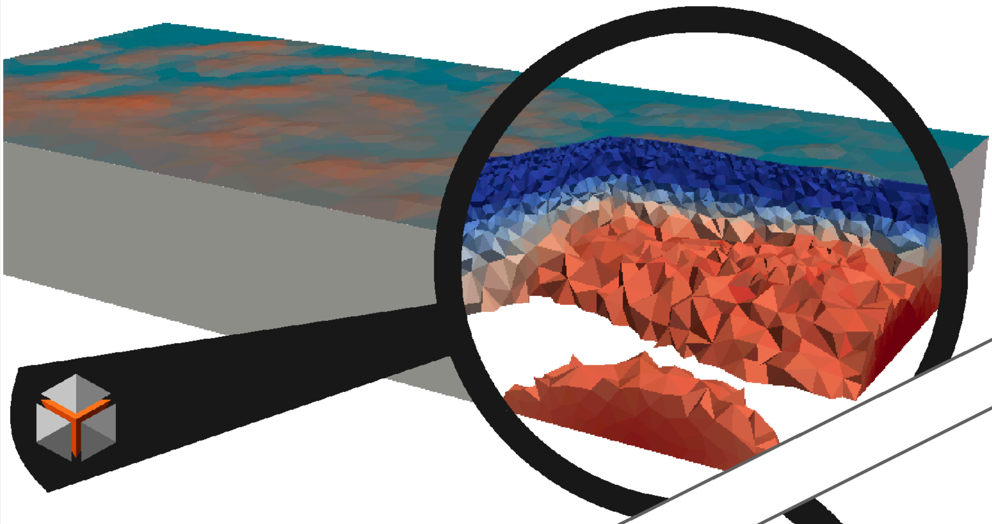
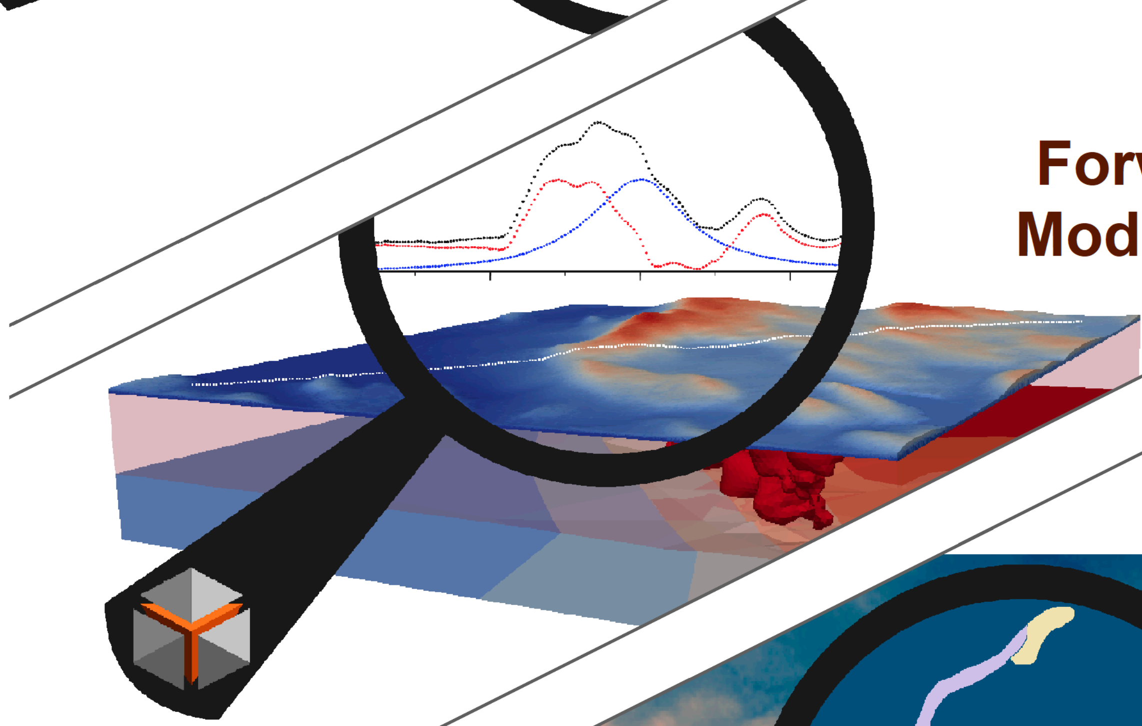
Geotexera
Geophysical Modelling & Inversion

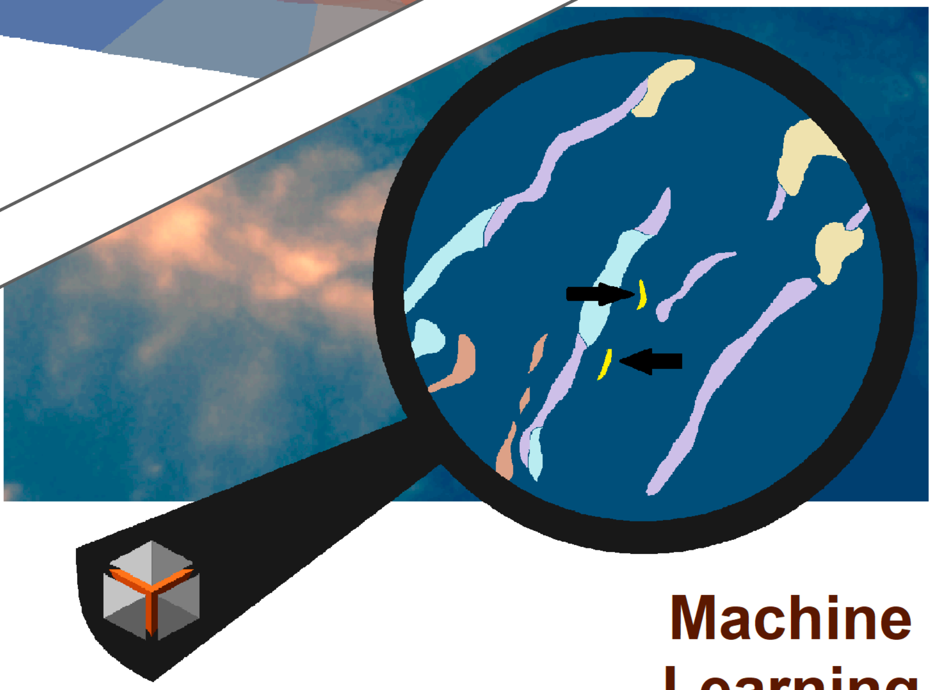
Overview of Services

Geophysical Inversion



Forward Modelling





Machine Learning

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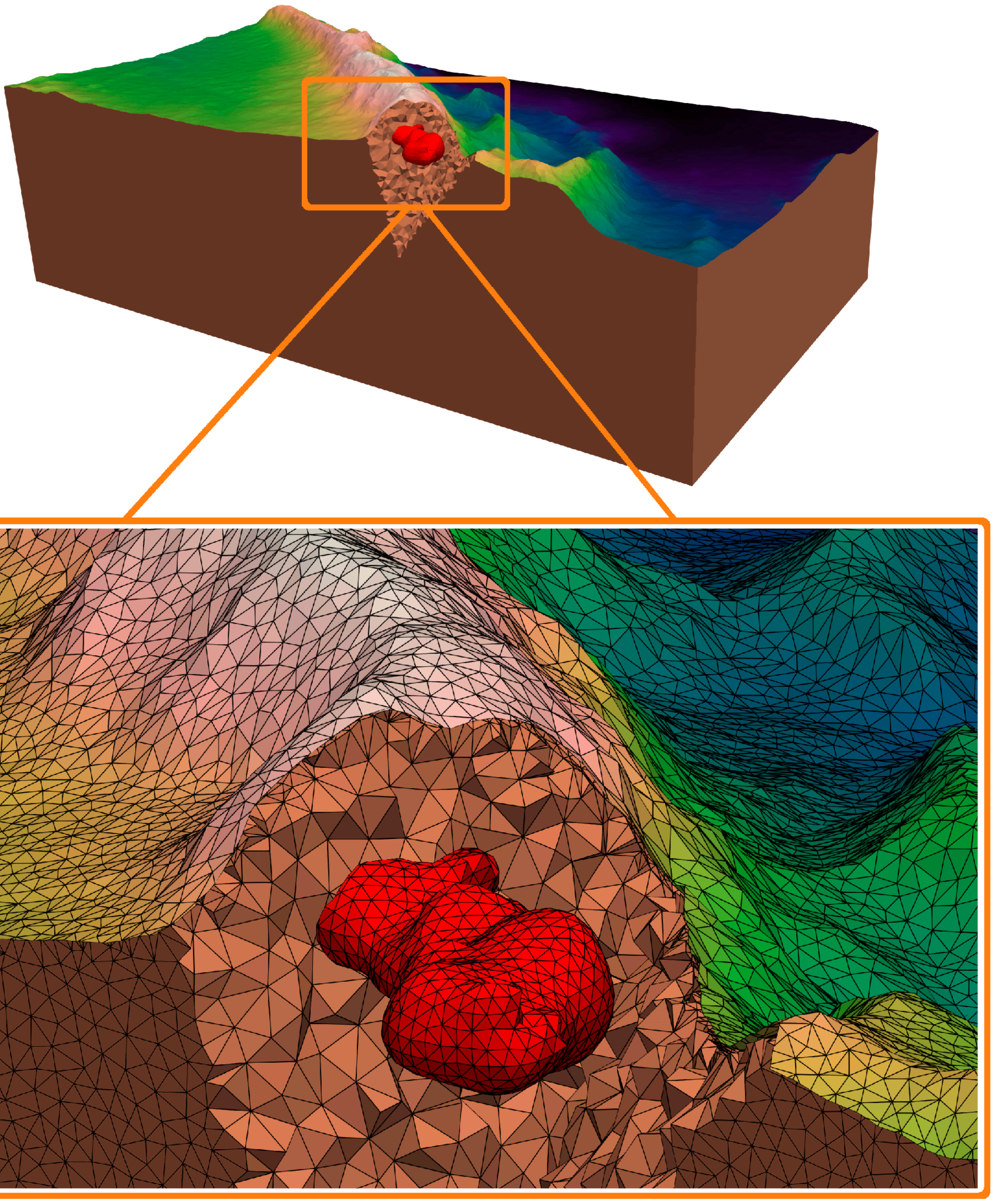
Unstructured Meshes

At Geotexera, unstructured (triangular and tetrahedral) meshes are used for geophysical inversions and modellings. This allows us to accurately add borehole information, geological contacts and high-resolution topography to our models.



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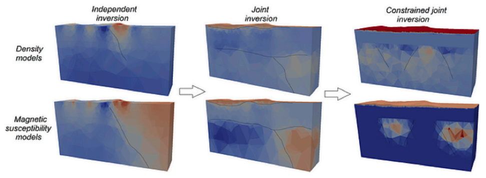
Geophysical Inversion

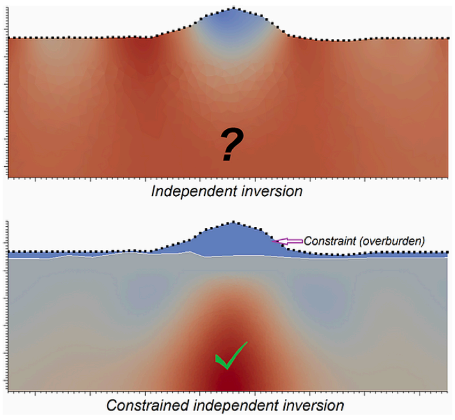
Geophysical inversion is the mathematical process of estimating the values of geological model parameters (such as size and depth) from a set of observed geophysical data. Simply put, an inversion can reconstruct geological structures from geophysical data. Independent single-property inversion can often encounter difficulties when the geology is complicated. Inverting a geophysical dataset jointly with another complementary geophysical dataset can solve and improve the construction of a single Earth model. This process is called joint inversion. Physical property data and drill-hole data can be used as constraints in both independent and joint inversions. Our new and modern codes and software enable us to invert magnetic, gravity, gravity gradiometry, magnetotelluric and first arrival travel-time seismic data. For 3D cases, we use unstructured tetrahedral meshes, the advantage of which is that it can honour the topography (as well as constraints) to as fine a resolution as the topography is known. Here are some real examples of our geophysical inversion services:

P.S. Because of the policy of real data, information on figures has been removed.



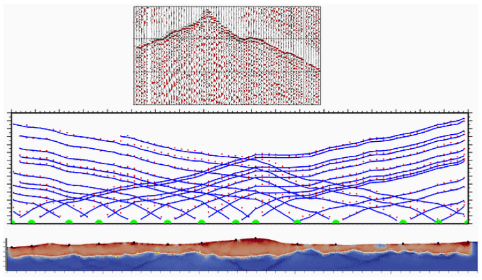
Gravity and Magnetic Inversions

Independent inversions of gravity and magnetic data are becoming more common at interpretation. However, we believe that joint inversions can significantly improve the results, especially after applying constraints.



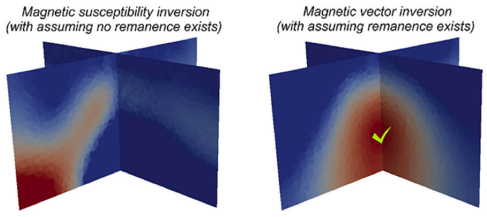
Constrained Inversions and Overburden Stripping

The geophysical responses (e.g., the gravity response) of exploration targets (e.g., deposits and mineralizations) can be masked by the variation of the overburden thicknesses. To solve this problem, we use new ways to separate the overburden contribution from geophysical data so that deeper targets can be detected and delineated by means of an innovative application of new, modern, state-of-the-art modelling and (constrained and joint) inversion of geophysical methods (such as seismic refraction, magnetic and gravity).



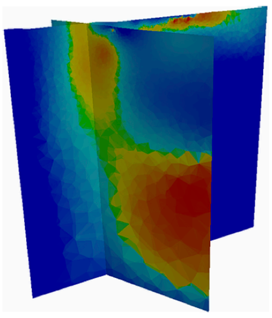
Tomography and Seismic Refraction Inversion

Tomography and the inversion of seismic refraction data give us a seismic velocity model of the subsurface. To obtain sharp boundaries between geological structures in the reconstructed model, we use advanced methods such as clustering in the inversion.



Inversion and Magnetic Remanence

The interpretation of magnetic data can be complicated because of the presence of magnetic remanence. However, inverting magnetic data for subsurface magnetization (magnetic vector inversion) as opposed to magnetic susceptibility (magnetic susceptibility inversion) can be a potential solution.



3D Inversion of Magnetotelluric Data

Natural source methods such as magnetotelluric (MT) are suitable for deeper exploration. In the shallow exploration, a transmitter can be used, which is referred to as control source MT (CSAMT). MT methods use electromagnetic signals to investigate the electrical resistivity of geological structures. MT exploration has been used in oil & gas, mineral, environmental, tectonic, geothermal and geotechnical explorations. Our 3D inversion code can reconstruct geological structures from MT data.

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Forward Modelling

Forward modelling is one of the main methods used for interpretation in which the data will be mathematically synthesized based on a physical or mathematical model with a given set of geometries and physical properties (such as density, magnetic susceptibility, conductivity and seismic velocity). The calculated data can be compared with real data. For the two datasets to be similar (fit each other), the geometries and physical properties in the forward model are adjusted. This process can be done repeatedly to reconstruct a model similar to the real geological structure. Forward modelling can also help us find the size and contribution of geological structures in geophysical data. Our new and modern codes and software enable us to model frequency- and time-domain electromagnetic, magnetic, gravity, gravity gradiometry, magnetotelluric and first arrival travel-time seismic data. For 3D cases, we use unstructured tetrahedral meshes, the advantage of which is that it can honour the topography to as fine a resolution as the topography is known. Here are some real examples of our geophysical modelling services :

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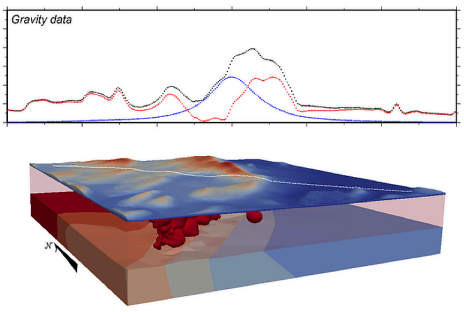
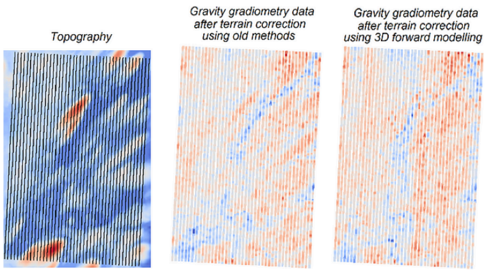


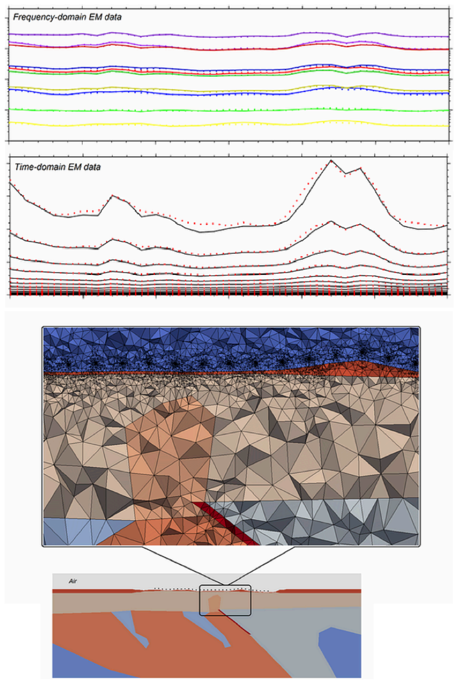
2D and 3D Gravity and Magnetic Modelling

The gravity and magnetic data involve variations in the density and magnetic susceptibility of geological structures. Therefore, forward modelling of gravity and magnetic data can give us a better understanding of the relationship between the data and variations in physical properties. The size, depth and density (or magnetic susceptibility) of heterogeneities have the strongest effects on gravity (or magnetic) data. Synthesizing the gravity and magnetic responses of different components of the geology can be done to assess the size and character of the various responses.



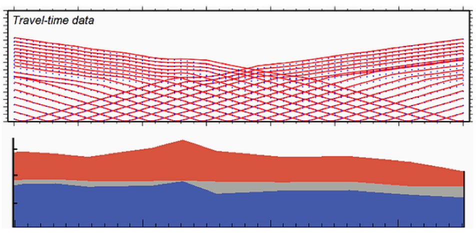
Gravity Gradiometry Terrain Correction using 3D Forward Modelling

Gravity gradiometry data can be strongly affected by topography. To eliminate this effect, leaving only the contributions from density variations in the subsurface, a terrain correction can be calculated and subtracted from the observed data. The terrain correction is typically computed using a Fourier-based technique. Such approaches can be efficient; however, we can use 3D forward modelling, which incorporates accurate topography as a means of more accurately computing the terrain correction. Data corrected using the forward modelling approach have less of a remnant topography signature than data corrected using the Fourier-based approach.



3D Electromagnetic Modelling

Electromagnetic (EM) geophysical methods can detect conductive structures in the ground. In the controlled source EM (CSEM) method, sources and receivers are loops of wires. The CSEM method can be categorized into frequency-domain (FDEM) and time-domain (TDEM) electromagnetic methods. EM methods can be used for a wide range of subsurface explorations. The investigation depth for TDEM is greater than for FDEM. Different systems have different applications. They can be sensitive to a different range of conductivities, and they can have different investigation depths. EM responses of different structures in complex geology can be confusing. Forward modelling can help us have a better understanding of EM responses coming from different structures.



Seismic Refraction (First Arrival Travel-Times) Modelling

Using the travel times between the source and the receiver, we can determine the depth of different geological boundaries and the elastic properties of rocks based on the difference in the seismic velocity and acoustic impedance of structures and materials. One of the main applications of seismic refraction is for determining the depth to bedrock. Exploration, however, faces many problems (such as hidden layers and blind layers). Forward modelling can be a suitable method for investigating the effects of different thicknesses and seismic velocities of geological layers on seismic refraction data.

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Machine Learning

Machine learning algorithms (MLAs, aka AI) are powerful tools used to recognize patterns in high-dimensional data. MLAs are efficient methods for producing geological maps or improving existing maps as well as predicting subsurface resources. MLAs can be categorized into two groups: supervised and unsupervised methods. Supervised methods utilise training data that are comprised of a set of known observations. These data train a classification model (in the MLAs), which enables us to predict the group/class labels of samples previously unseen. The unsupervised method has no training data, and it identifies groups/classes within data. In MLAs, we can use geophysical, geochemical, radiometric, geological and remote sensing data.

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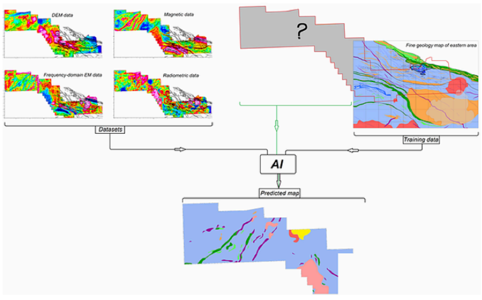
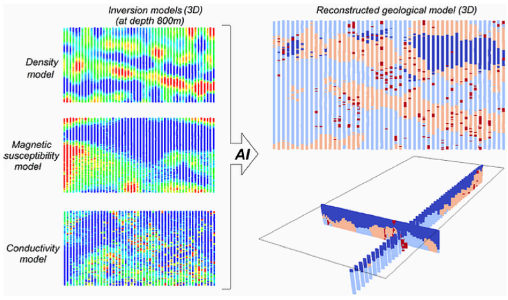


Prediction & Classification

Numerous datasets (including geophysical, geochemical and geological) that are covering the study area can provide good knowledge of the subsurface. However, the integration of many datasets can be challenging for the interpretation as well. MLAs can overcome this challenge using an automatic method to recognize patterns in datasets. MLAs are efficient methods for producing geological maps or improving existing maps. They start with training, and, when learned, patterns will be applied to the datasets to generate predictions for data-driven classification and regression problems. MLAs show a good performance in predicting categories from training data. MLAs are one of the most effective methods for the prediction and classification of mineralizations as well as lithological units and geological structures.



Combining AI and Inversion

While geophysical inversions reconstruct geological structures based on physical responses and geometries, machine learning methods use patterns in data to provide predictions and classifications (e.g. of lithology or mineralization). For a geometry (structure), different physical properties (such as density, conductivity, etc...) give different types of geophysical data. But in the inversion, different types of geophysical data from one geometry with different physical properties might not give the same model. Therefore, the geological models reconstructed from the inversion of geophysical data might be different. At this point, MLAs can find the pattern in the models to provide a single model using classification.

Geotexera Inc.

Reconstructing geological structures from geophysical data using modelling and inversion methods for mineral, metal, oil&gas, water, environmental and geotechnical explorations.

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Canada
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