Learning about Ontario's Paleozoic Geology

with Virtual Reality Google Expedition Tours

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Abstract

How well can you interpret or place into context the different geological features or rock types that are exposed along roadways, rivers, coastlines or construction sites? Here in the Department of Earth and Environmental Sciences at the University of Waterloo, we recognize a gap between learning foundational geoscience knowledge (i.e. in traditional classrooms and lab settings) and applying this knowledge during field experiences. To bridge this gap and better prepare students for field experiences we suggest using virtual reality.

The Google Expedition Kit funded by the Dean of Science Undergraduate Teaching Initiative was chosen as the best entry level system because it is cost-effective, self-contained, already tested and versatile for teaching up to 20 people. Here we present the perceived advantages and disadvantages of this system to provide immersive learning experiences for improved understanding of Ontario's Paleozoic geology. Initial use of this VR Kit has shown it can be used successfully to investigate Paleozoic rock outcrops across Ontario by using existing and student-created Tours, as well as self-guided and leader-guided Tours. There was increased motivation and engagement among students, improved familiarization and connections among a variety of outcrops in space and time. And there was also enhanced meaning and context for the many Paleozoic rock layers in Ontario, and an increased number of insightful questions. Although field experiences will always play a vital role in university geoscience education, virtual reality can help in improving understanding and compliment field experiences through its uniquely immersive capabilities. We suggest this would also be effective in professional geoscience practice and everyday life.

What is Virtual Reality?

Simulated 360° environments that are viewed with a headset (Oculus Rift, HTC Vive, Samsung Gear VR). The headset projects an image, which can be viewed from different perspectives as the user changes the orientation of their head. The degree of immersion scales with cost and technical proficiency. Basic virtual environments can be created with static 360° photospheres, while more advanced VR experiences allow users to view a 360° video or move around in a simulated environment.

Benefits of VR in Geoscience

- Bridges application gaps of knowledge between class and field environments
- Allows virtual travel and investigation anywhere in the world, accommodates persons with disabilities (cost and time efficient training)
- Immersive simulated environments increase and student interest and engagement
- Familiarises students with locations to better prepare for field work and professional practice. Also mitigates anxiety before field work
- Exploration from different perspectives (eye-level, drone heights) and scales (ability to zoom in or out on features)
- Mechanism to train in one area and extrapolate to other areas (improve observation and prediction skills before and after fieldwork)

Limits of VR in Geoscience

- Distractions within virtual environments → can be mitigated via real-time teacher guiding, point-of-interest markers, and annotations
- Motion sickness and disorientation → can be reduced using the guide's pause feature, regular fullscreen viewing mode, and as a compliment to lessons (rather than a replacement)
- Certain configurations and equipment can be costly for large classes → More feasible, entry level VR experience alternatives (e.g. Google Expeditions Kit)
- Necessary power and internet service isn't directly available in the field → Can use a portable battery and download Tours to a host tablet/smartphone to guide Expeditions offline.

Simple VR Content Creation

Creating VR content can be a simple process supported by free Google software. Currently, we are using Google Street View as a repository of 360° images (photospheres), in order to create Tours. By selecting already-existing photospheres of geologically relevant locations, we are able to create Tours with Google Tour Creator and view them through the Google Expeditions mobile app or the Google Poly website. We are starting to capture our own images with a 360° camera to align with specific learning outcomes.

Google Street View

360° photos that already exist in Google Street View can be imported into a Tour, directly within Google Tour Creator. Cell phones are also used to create 360° photos easily using Google Street View. Google Street View stitches and georectifies many individual photos from one location to create a single 180° or 360° photo.

A 360° Camera

Capturing 360° photos and videos in certain geologically important areas are key to connecting geologic knowledge with real simulated immersive environments. 360° camera photos can be uploaded to Google Tour Creator.

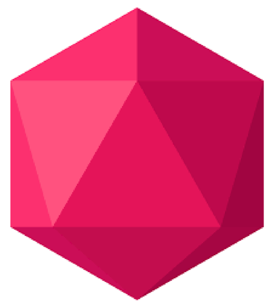
Google Tour Creator

Google Tour Creator is used to spatially link a sequence of 360° photos/videos, with the ability to add and layer text descriptions, points of interest, and 2D photos/images.

Google Expeditions

A virtual tour app that can be used to view/host Google-approved Tours from others, or self-created Tours. These Tours can be viewed online or downloaded and viewed offline. Tours can be broadcast from a single device, allowing a host to guide other users. Tours can also be self-guided and viewed independently by the creator. Guiding Tours allows the host to draw attention to specific areas of a picture using marker icons and drawing capabilities in real time.

Google Poly



Poly.google.com is a website used to view (but not host) all Tours made with Google Tour Creator. These Tours can be viewed on a desktop or mobile device.

Google Expeditions Kit

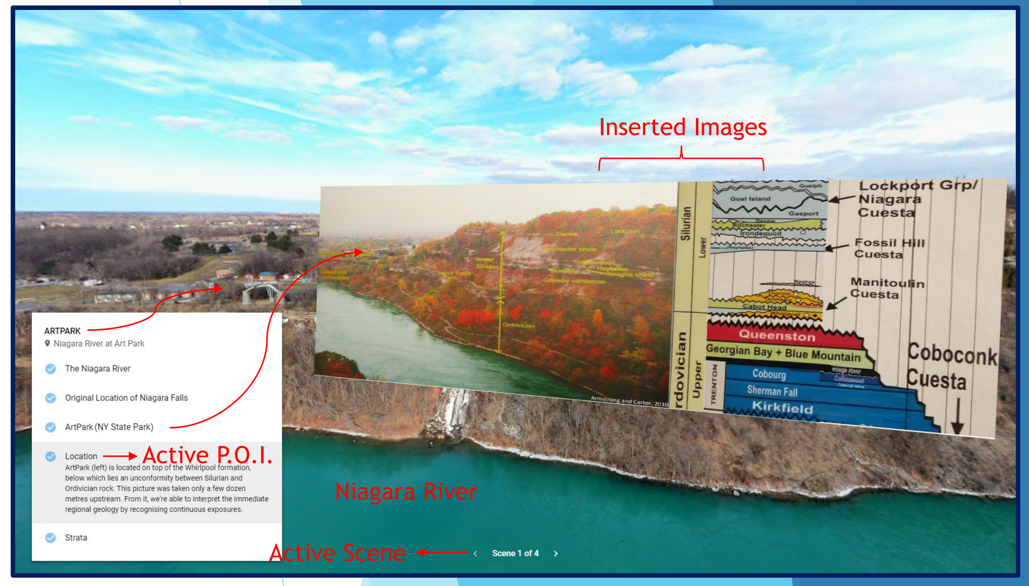
We use the Google Expeditions Kit because it has been tested, is cheaper then alternative kits, is mobile and durable. We have 20 student headsets and phones, a teacher tablet, router, and battery to provide a uniform VR experience in the class or field.

Student-Inspired Virtual Tours

Directly below are examples of VR tours created by Henry, Jen, and John with some ideas inspired by Tours created by students in EARTH 235 (Fall 2019) – Stratigraphic Approaches to Understanding Earth's History. Examples showcase the variety of technical capabilities in Expedition Tours that support real-time teaching and application of foundational knowledge in simulated or real field experiences. These example Tours can be viewed at the poster session.

Outcrops Along the Niagara River

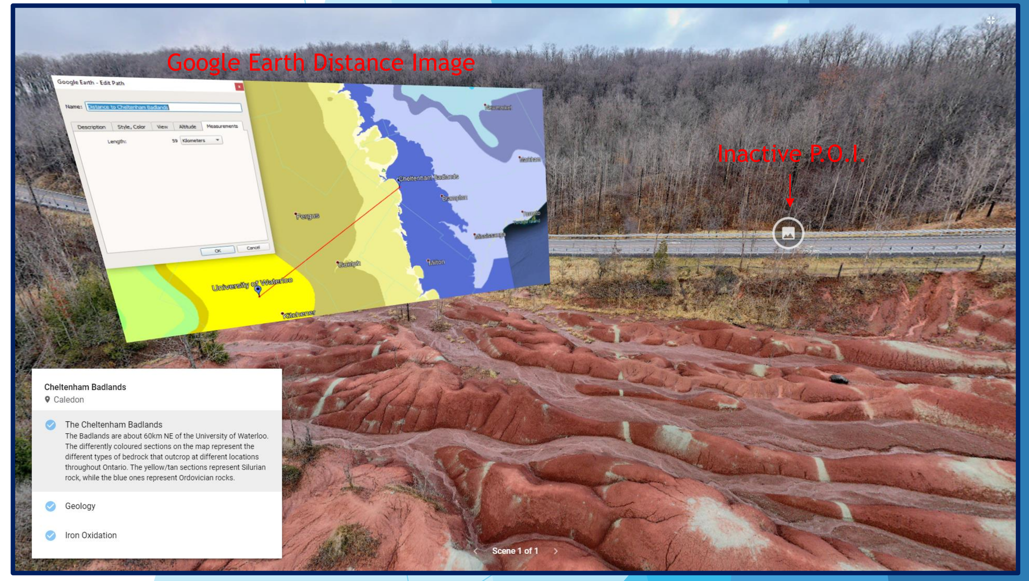
- Ability to trace a mostly continuous exposure for kilometres, extending beyond a known location
- Can improve and apply observation and correlation skills regarding bedrock stratigraphy, remotely
- Drawing attention to important or unique units
- Ability view and interpret an exposure from different perspectives (i.e. upstream/downstream and water-level/drone height)



Bedrock of different ages in SW Ontario

Key Themes and Features

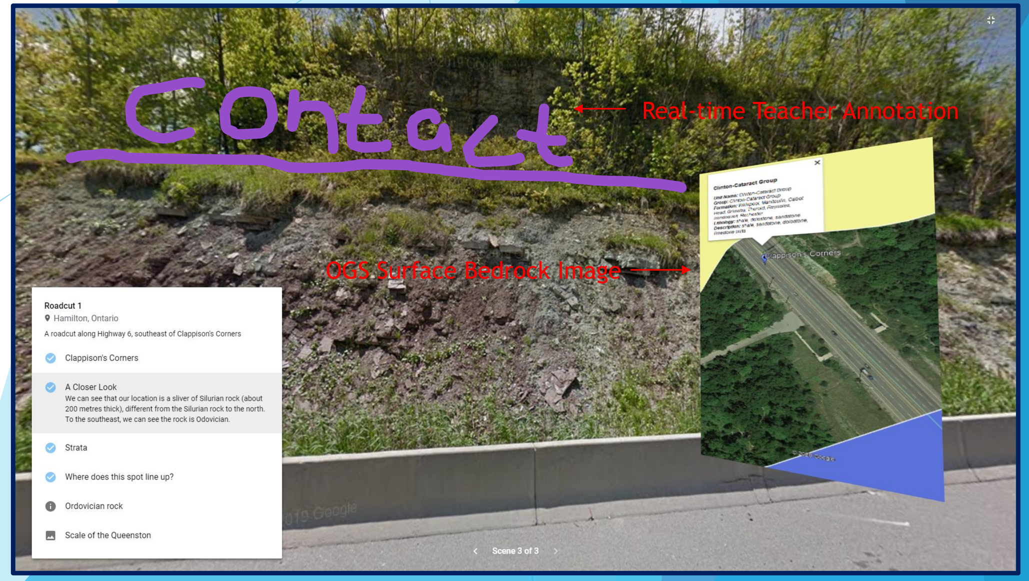
- Able to view and analyse various, spatially separated bedrock outcrops
- Shows unique perspectives of exposed bedrock required for fieldwork preparation
- Can determine rock type and age and translate 2D map data (i.e. OGSEarth or ROCKD) to 3D media



Road Outcrop at Clappinson's Corners

Key Themes and Features

- Can remotely investigate mapped geological contacts in 3D (i.e. Ordovician-Silurian)
- Can compare a plan view (Google Earth aerial photos and OGSEarth Bedrock Geology layers) in 3D or with a cross-sectional view along roads
- Contextualises the scale of different bedrock units



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Recommended Readings

- *Virtual field experiences in introductory geology: Addressing a capacity problem, but finding a pedagogical one*, Dolphin et al. 2019
- *Virtual Field Sites: losses and gains in authenticity with semantic technologies*, Litherland & Stott 2012
- *Affordances of Mobile Virtual Reality and their Role in Learning and Teaching*, Minocha et al. 2017