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Google Earth Model of the southern Alisitos Arc crustal section, Baja California

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Section 1: Geologic Setting of the Southern Alisitos Arc, Baja California, Mexico

The Google Earth Model provides a 3D visualization of the transition from volcanic and hypabyssal rocks of island arc upper crust through the transition to coeval underlying and plutonic rock basement. The Alisitos arc is a ~600 km long x 50 km wide accreted oceanic arc terrane (Fig. 1a; Gastil et al., 1975; Fackler-Adams & Busby, 1998; Busby, 2004) that formed during the Early Cretaceous in response to intra-oceanic subduction marginal to Mexico (Busby, 2004; Busby et al., 2006). Within the southern region of this arc, the 'Rosario segment' is a 50 km-long and 7 km-deep segment (Fig. 1b) that exposes well-preserved and structurally intact upper- to mid-crustal units (Morris et al., 2019; Busby et al., in revision). Within this segment, exposures of a heterogeneous upper volcanic crust transition downwards into underlying plutonic rocks and provides an exceptional location to study the volcanic rock to plutonic rock transition within juvenile arc crust.

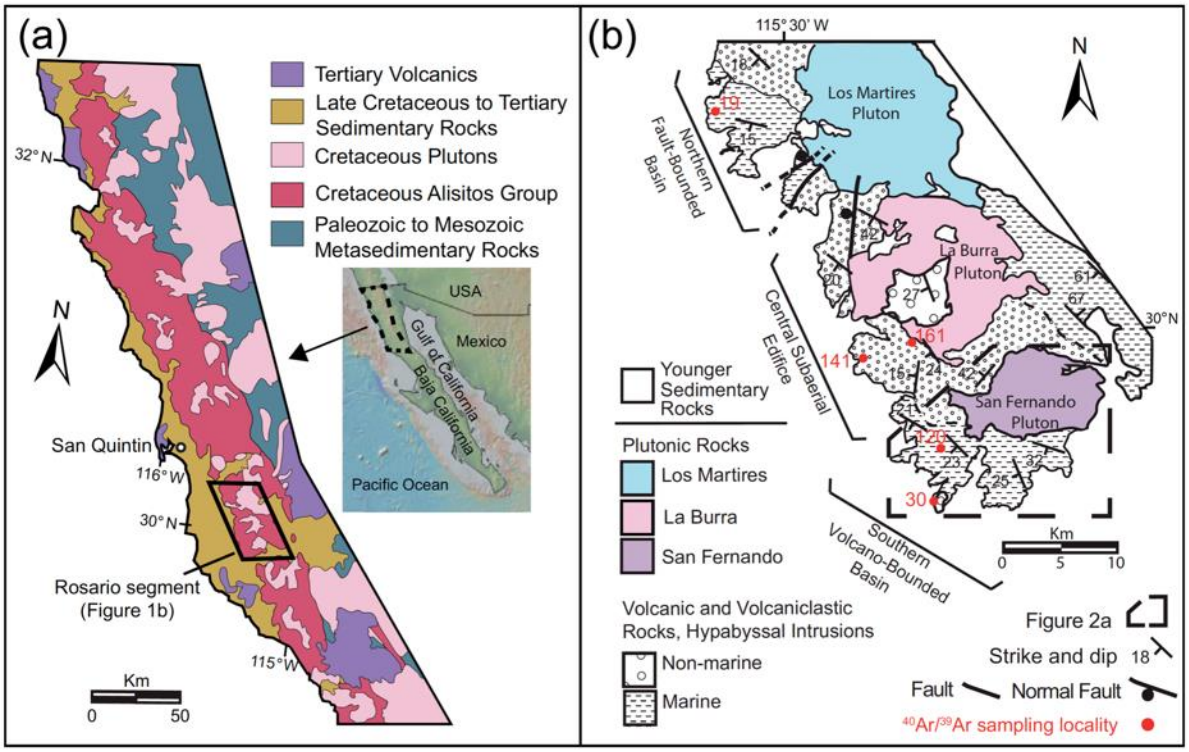


Fig 1 - From Morris et al., 2019

The Rosario segment is divided into its three volcanic centers (Fig. 1b) or 'sub-segments', from north to south: a northern fault-bounded basin, a central subaerial edifice, and a southern volcano-bounded basin (Busby et al., 2006). Each of these centers is underlain by plutons that intrude upward through the volcanic stratigraphy, essentially cannibalizing the base of the volcanic pile. These plutons are (from north to south) the Los Martires, La Burra, and San Fernando plutons (Busby et al., 2006). The volcanic section is up to 7 km thick, and is

unconformably overlain (to the west) by Late Cretaceous to Tertiary sedimentary rocks (Fig. 2 and 3; Morris et al., 2019; Busby et al., in revision and references within).

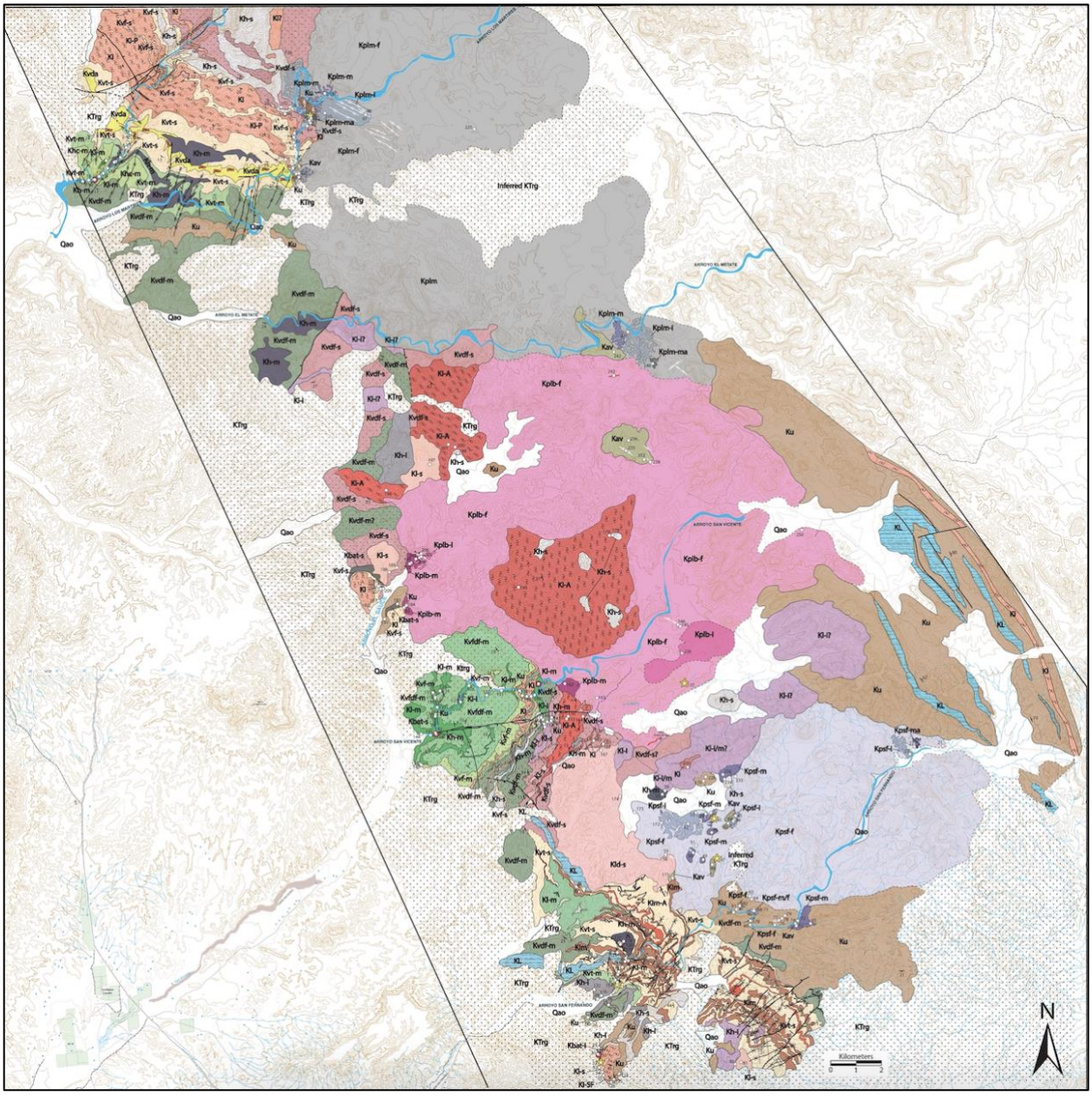


Fig 4a - From Busby et al., in revision

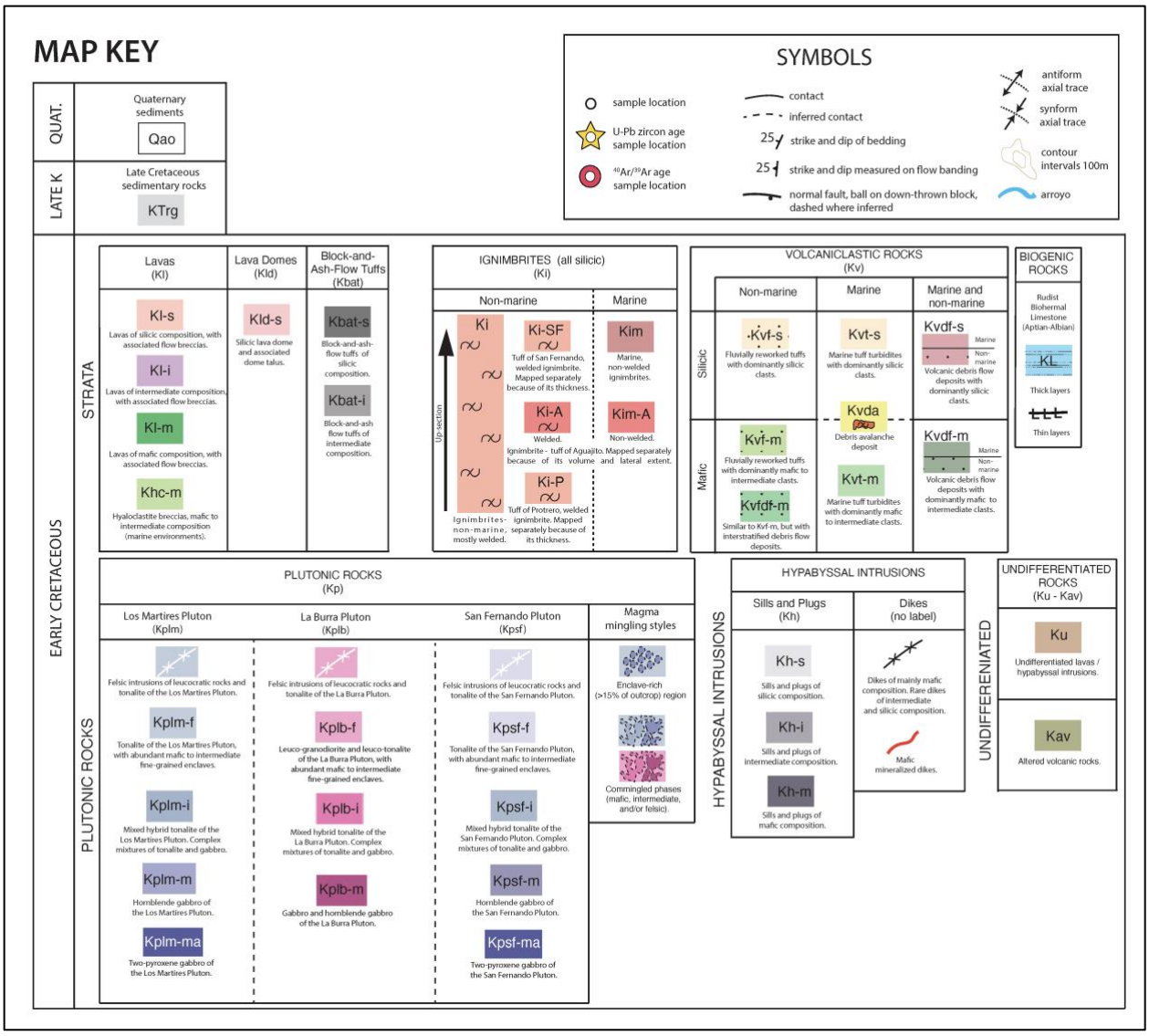


Fig 4b - From Busby et al., in revision

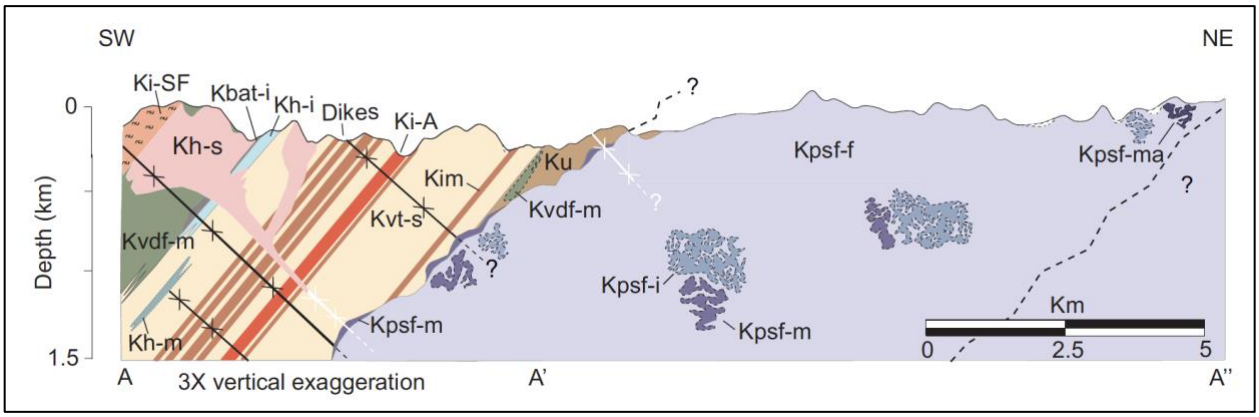


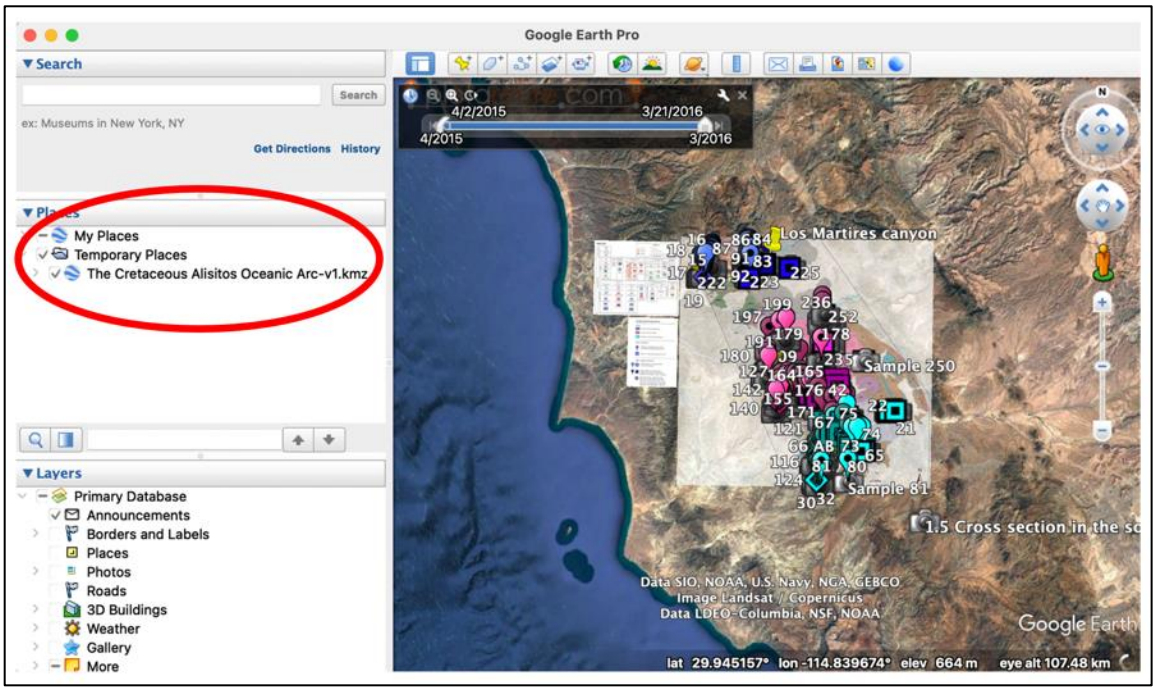
Fig 3 - From Morris et al., 2019

Here, we present a 3D model of the southern Alisitos Arc (Rosario segment) that provides a highly accessible and virtual way to explore the three distinct volcanic centers and observe the various rock units, field relationships, textures, and geochemistry that occur within this remarkably exposed shallow arc crustal section.

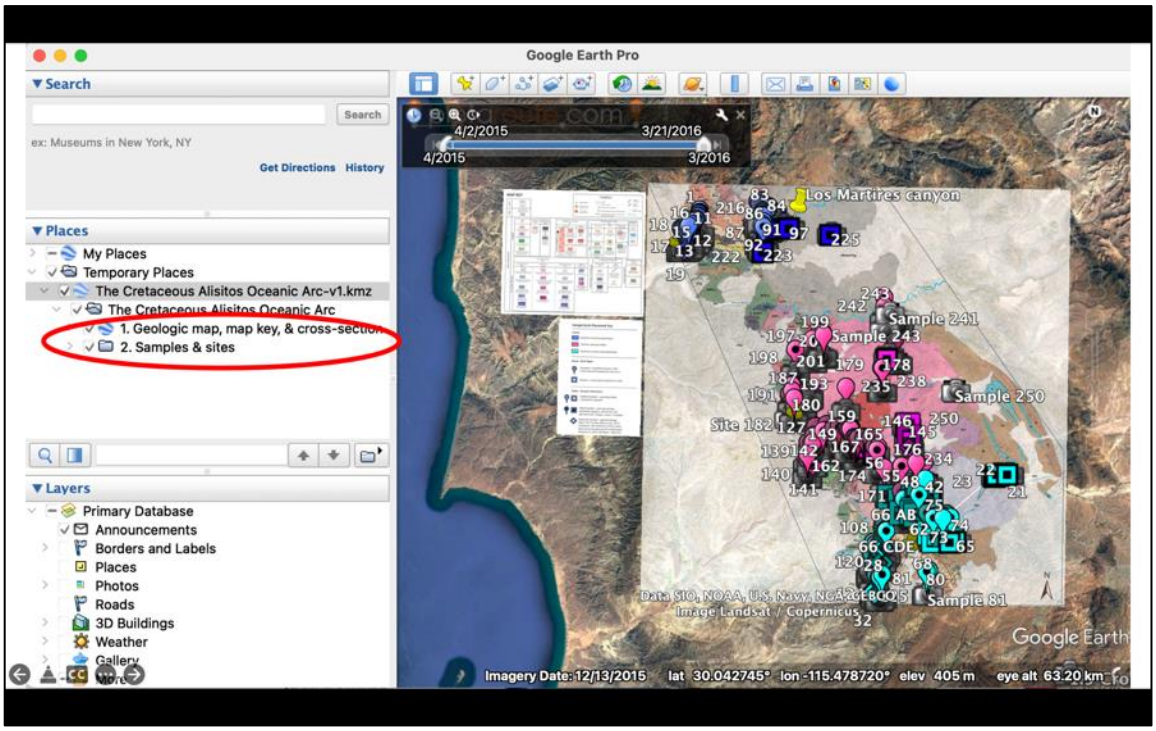
Section 2 below provides an introduction to how to use the 3D Model, and in Section 3 we provide a suggested tour through the transition from stratified volcanic rocks through to the plutonic basement.

Section 2: A step-by-step guide on how to use the 3D Model

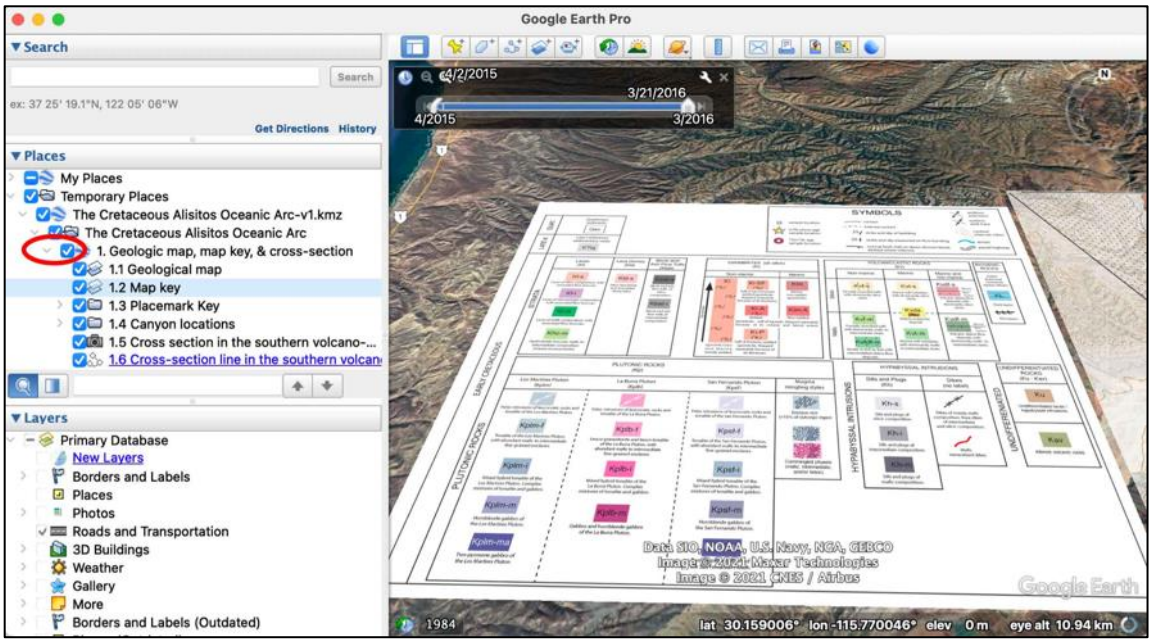
1. A video outlining the steps below is available here: https://youtu.be/G82kvwsLTIo?t=1
2. Download Google Earth to your appropriate device: https://www.google.com/earth/versions/
3. Open **3D_Model_files.zip** folder under '**Additional Files**' link on the CEDAR page
4. Click on the **kmz** file (i.e., The Cretaceous Alisitos Oceanic Arc-v1.kmz). **Note this kmz file is what we refer to as the '3D Model'.**
5. Wait (5-10 seconds) for the **kmz** file to load automatically in Google Earth
6. The **kmz** file will load under 'Temporary Places' (like so):



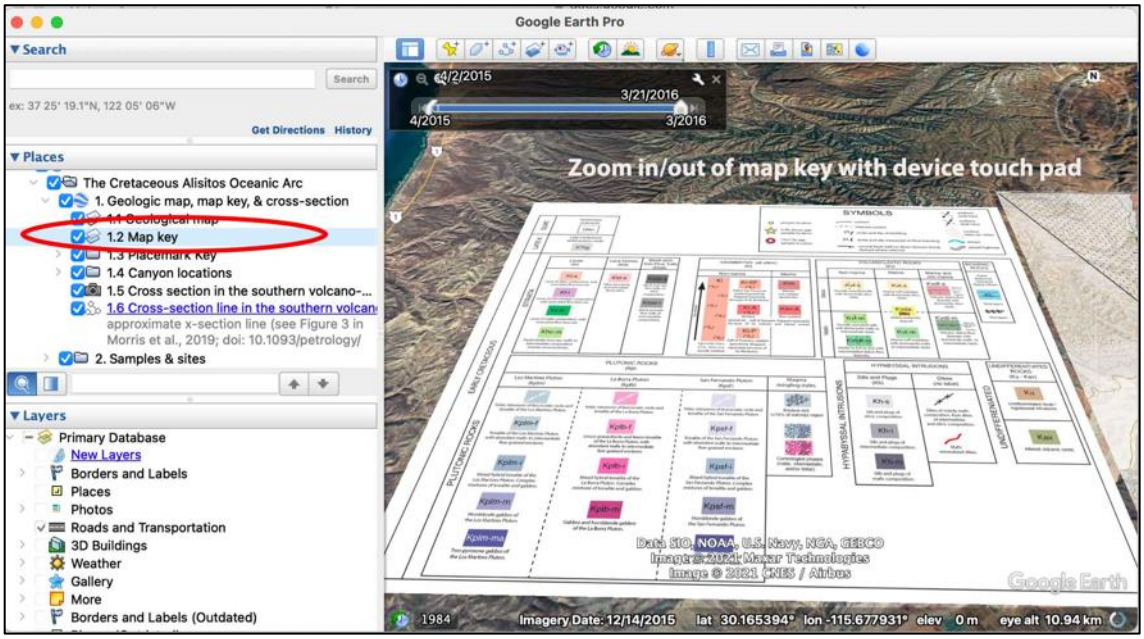
7. Save the **kmz** file to your '***My Places***' by going to '**File --> Save --> Save to My Places'** (saves within Google Earth) or save to you own desktop/device by going to '**File --> Save --> Save place as…**' and choose your own personal location to save it to.
8. The 3D Model is organized into two main sections:
   1. Geologic map, map key, & cross-section; and
   2. Samples and sites



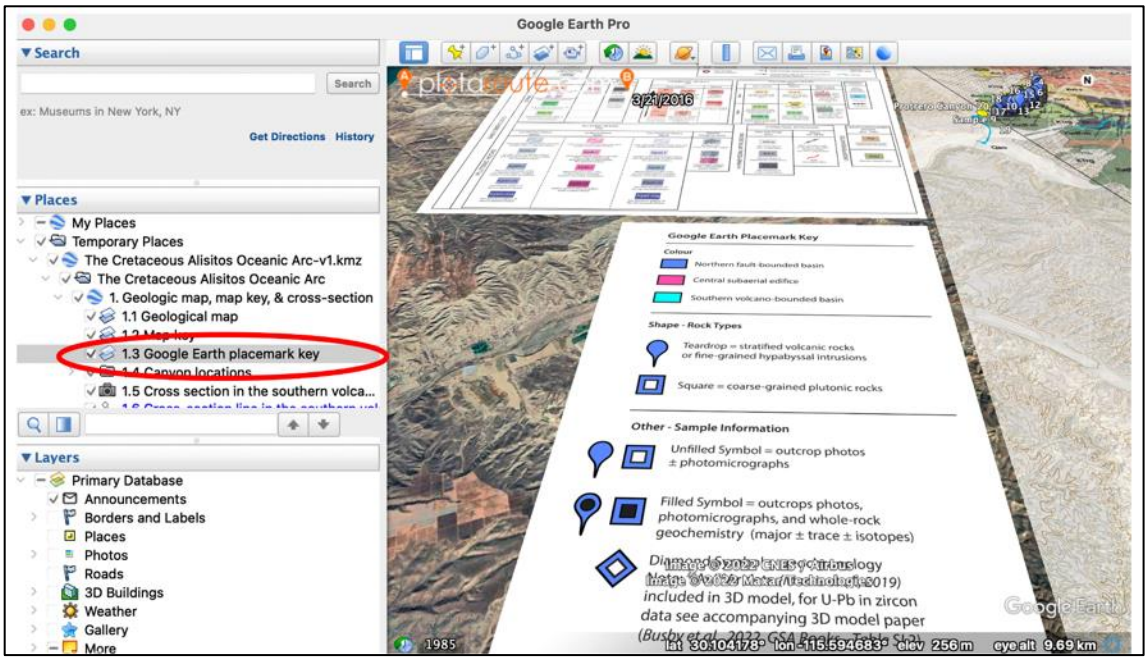
9. To access the contents within section ***1. Geologic map, map key, & cross-section*** click on the 'grey arrowhead' just left of the section title:



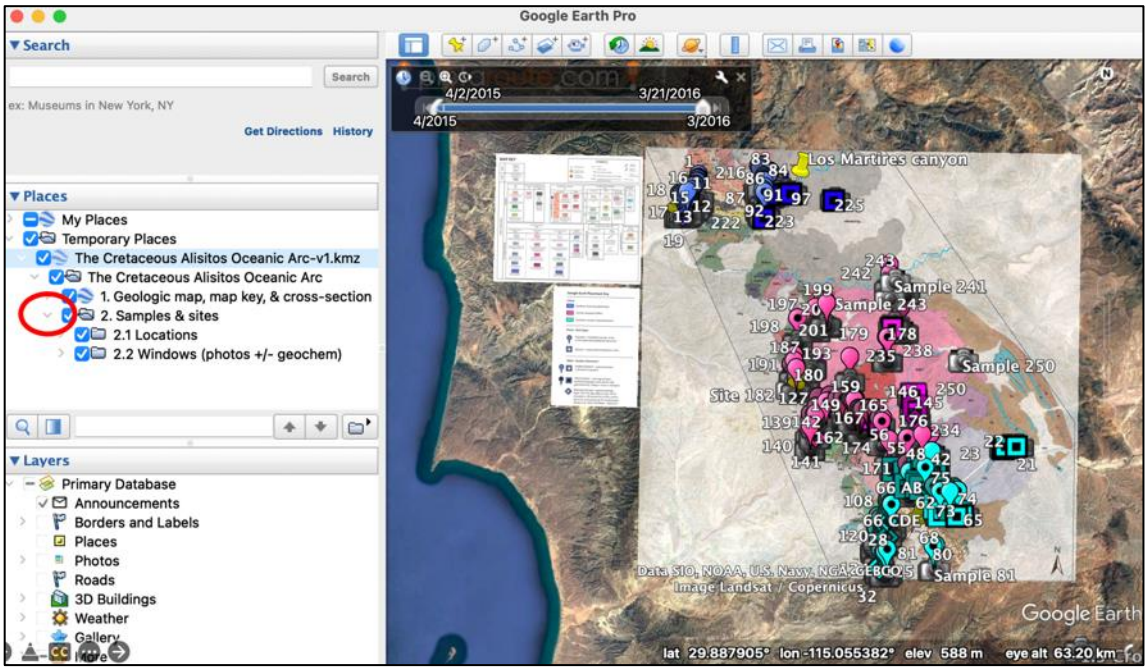
This will make the contents of section 1 visible (Geology map, map key, etc), where you can access the contents as you need. For example, to see section **1.2 Map key**, which describes the map unit labels, double-click on '1.2 Map key', and the model will relocate you to the map key where you can zoom in/out with your device's touch-pad or mouse.



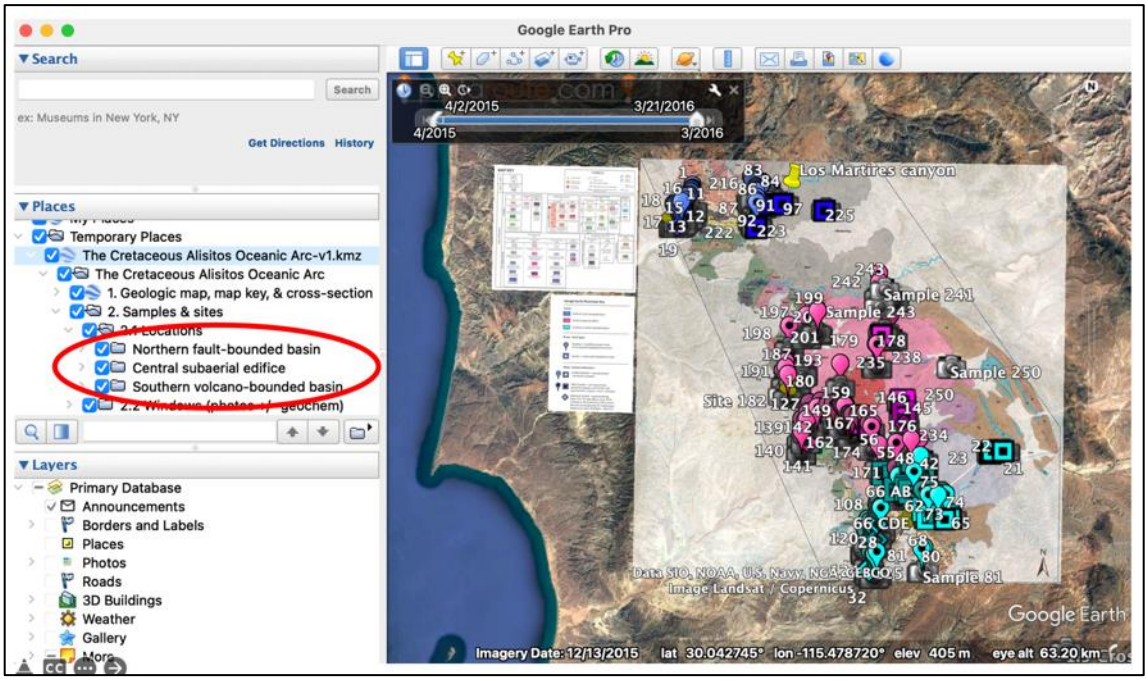
10. A legend for the Google Earth Placemarks is also available in section **1.3 Google Earth placemark key**:



11. All outcrop information (locations, photos, ± geochemistry) is located in section ***2. Samples & sites***. Click on the 'grey arrowhead' just left of the section title to make the contents visible as so:

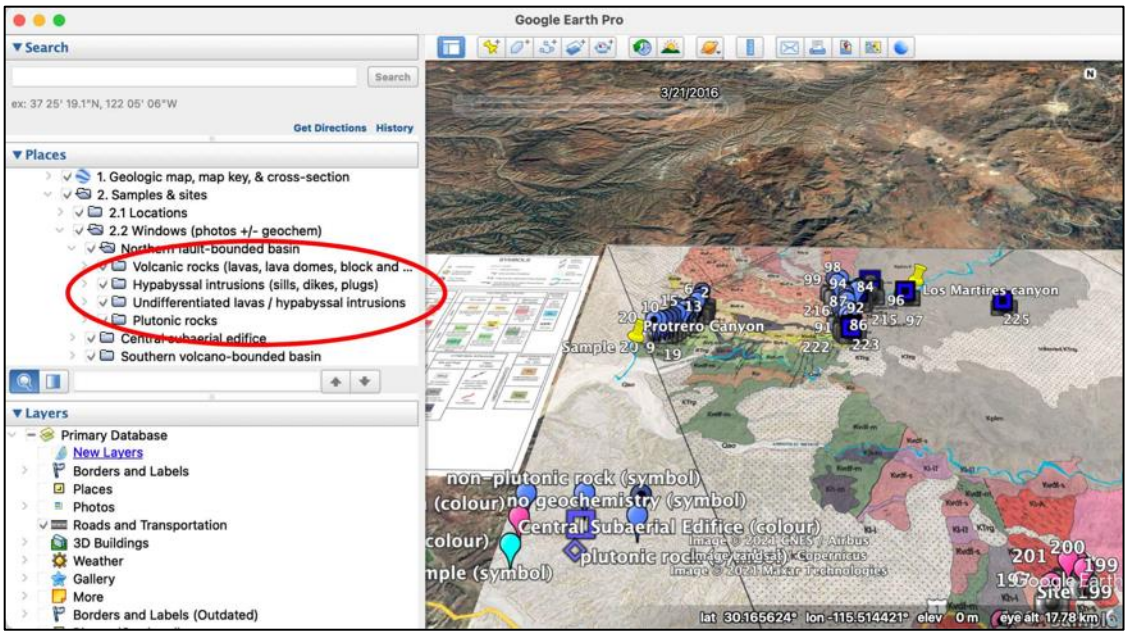


12. You will see two subsections - ***2.1 Locations*****;** and ***2.2 Windows (photos +/- geochem)***. Both of these subsections are organized into the three volcanic centers within the study area: ***Northern fault-bounded basin***; ***Central subaerial edifice***; and the ***Southern fault-bounded basin***.

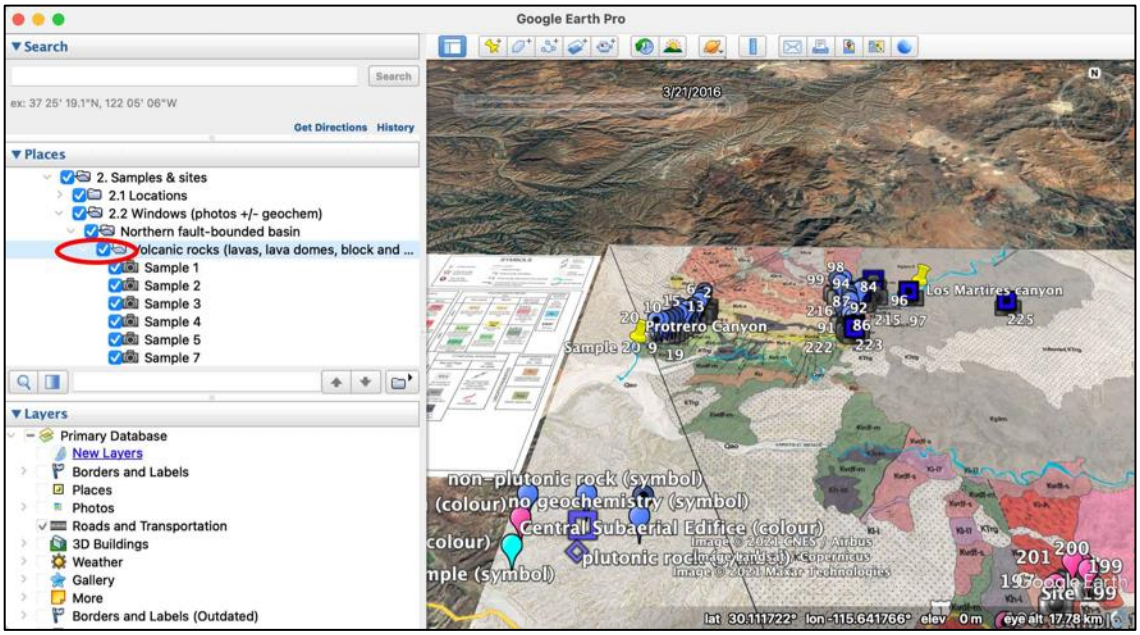


13. Subsection ***2.1 Locations*** includes specific outcrop 'locations' (Lat/Long), which are also available for easy access/download in the '**3D Alisitos Arc Model_outcrop summary table.xlsx**' table available within the **3D_Model_files.zip** folder under the '**Additional Files**' link on the CEDAR page.

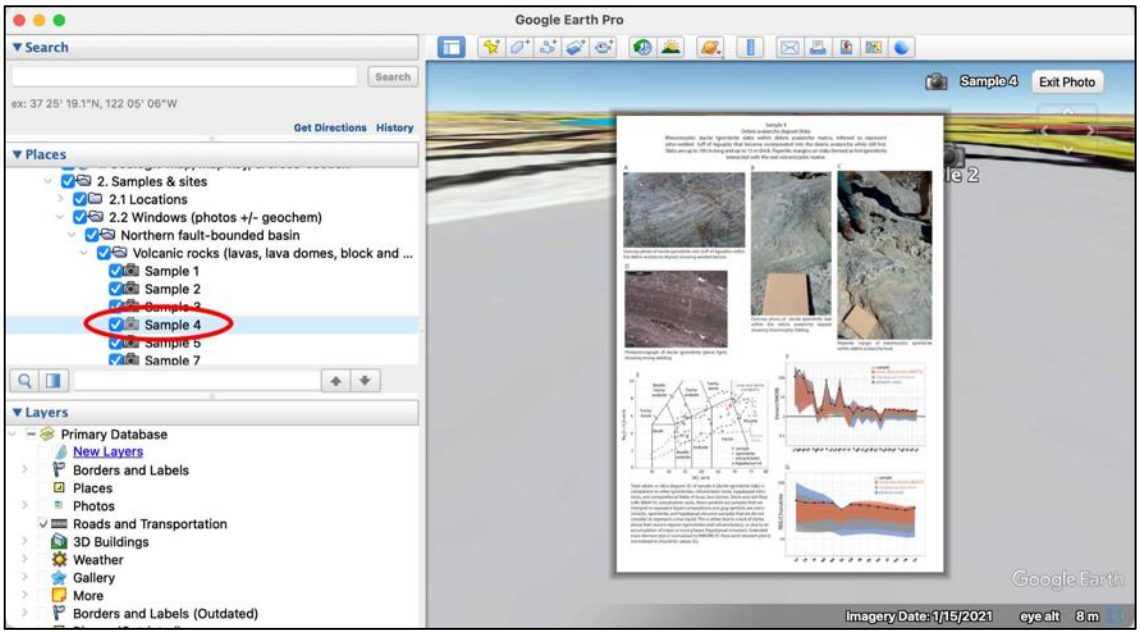
14. Subsection **2.2 Windows (photos +/- geochem)** includes all outcrop information (field photos, field descriptions, +/- photomicrographs, +/- geochemistry, and +/- geochronology). This subsection is organized into the three volcanic centers **(Northern fault-bounded basin; Central subaerial edifice, Southern fault-bounded basin)**, and FURTHER into separate rock units which we have categorized as: a ***Volcanic rock (lava, lava dome, block and ash flow tuff, or ignimbrite or volcaniclastic rock)*****;** a ***Hypabyssal intrusion (sill, dike, or plug)***; a ***Undifferentiated lava/hypabyssal intrusion***; or as a ***Plutonic rock.*** Further descriptions to how field relationships were established is described within the accompanying paper by Busby et al., in revision.



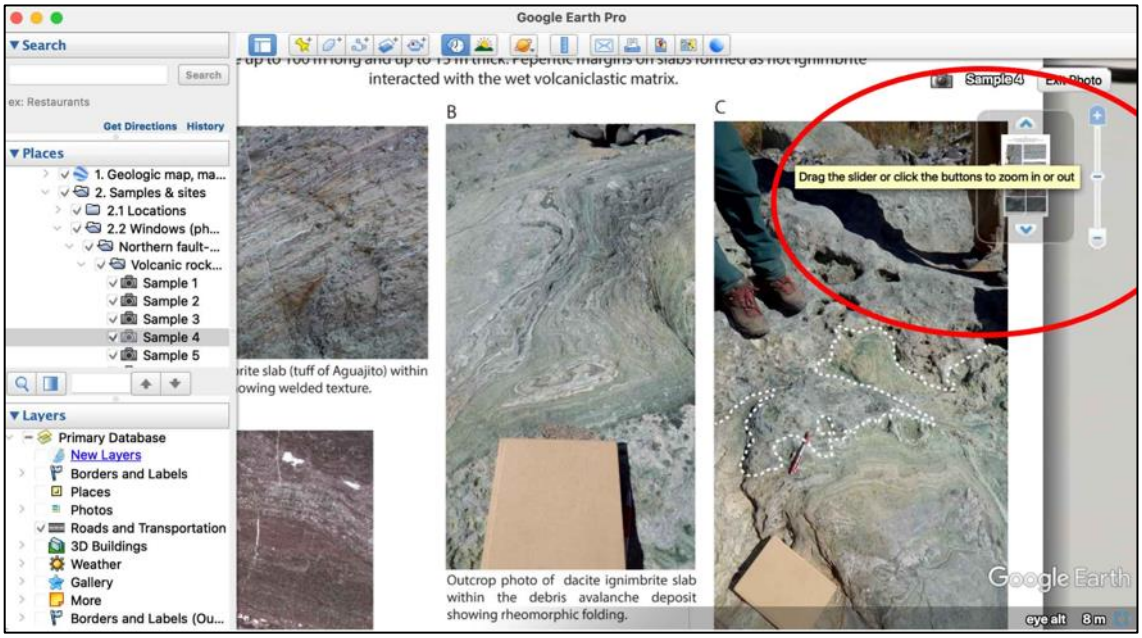
15. To observe an outcrop '**window**' and field information for a specific site, make the contents of the volcanic center folder visible by clicking on the 'grey arrowhead', which will display the rock type folders (i.e., ***Northern fault-bounded basin --> Volcanic rocks (lavas, lava domes… etc***). Then click on the 'grey arrowhead' beside the rock type folder to display the available outcrop windows like so:



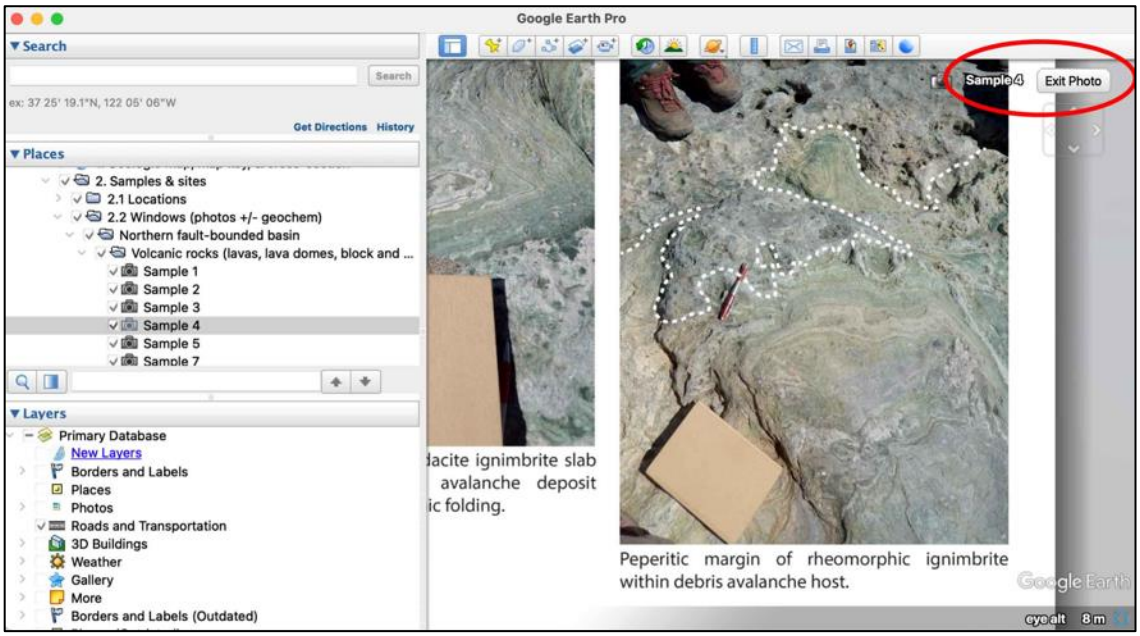
16. To observe the outcrop '**window**', simply double-click on the sample you are interested in (i.e., Sample 4)...



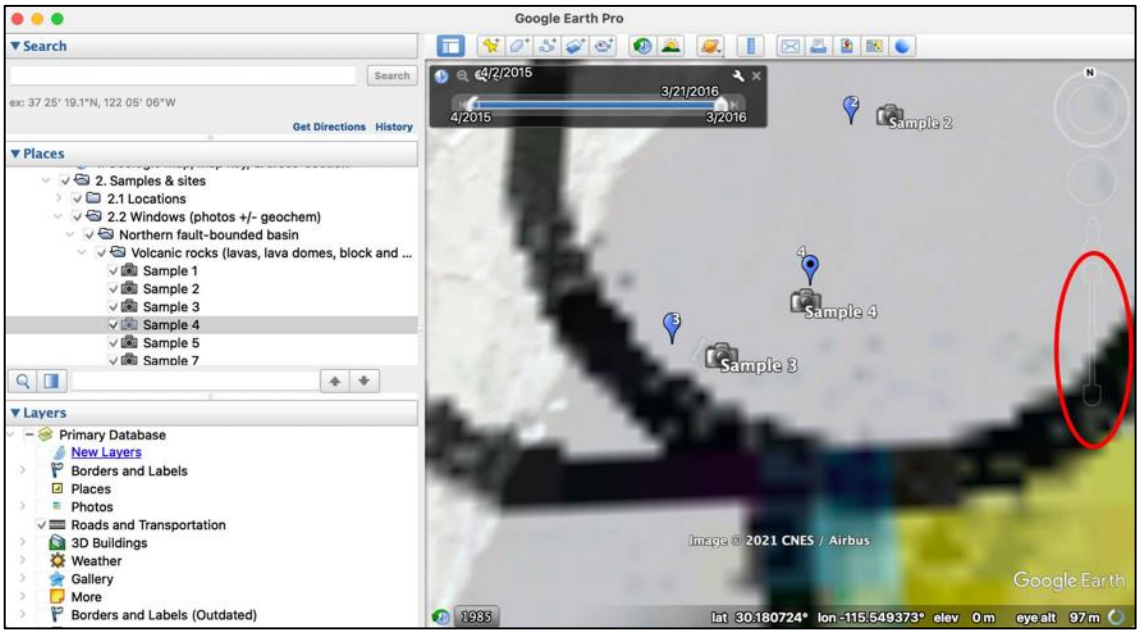
17. You are now in the unique file outcrop **'window'** and can zoom in/out of the window (via touch pad on your device or using the scroll bar to the right of the screen - circled in red below). These windows have been produced with a resolution that should allow you to see field characteristics outlined, such as the peperitic margins shown here:



18. To exit the window, which will take you out of the outcrop window and back to the map, simply click on the ‘exit photo’ button in the upper right hand portion of the screen circled below:



19. This will take you back to the main map, where you can zoom in/out via touch pad on your device, or by using the zoom in/out scroll bar on the right of the main google earth window (circled in red below):



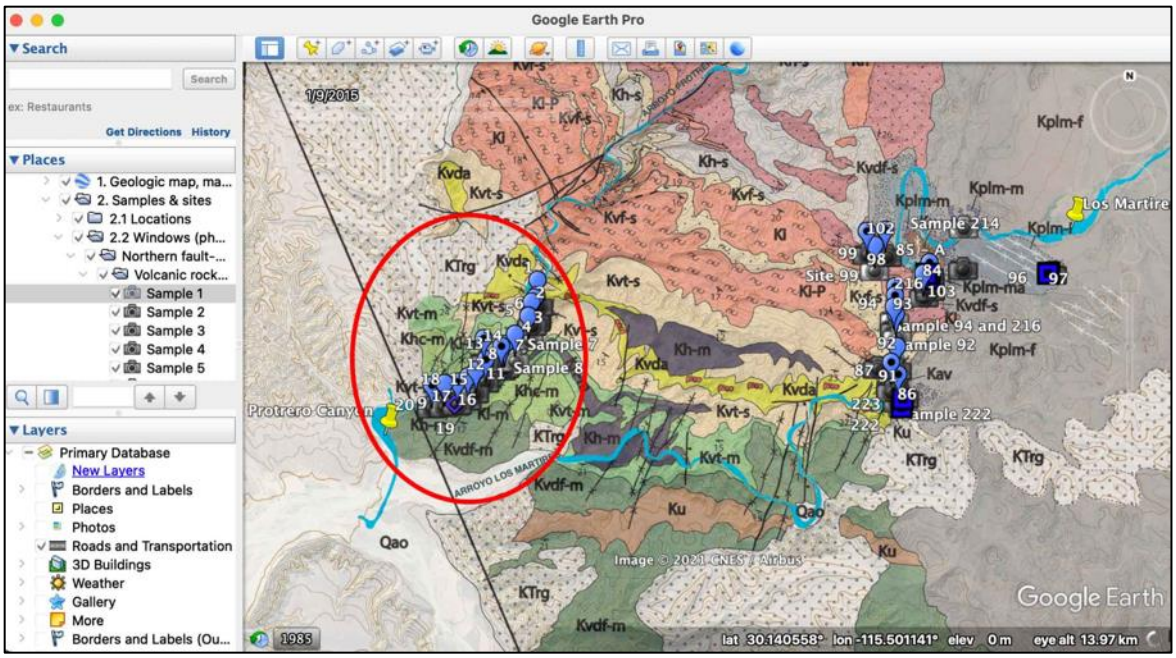
20. We suggest the best way to navigate this 3D model, is to: 1) search through the outcrop summary table (***3D Alisitos Arc Model_outcrop summary table.xlsx***) to narrow down the outcrops you are interested in; or 2) follow our suggested volcanic rock to plutonic rock transition outlined below (see section 3.0); or 3) just look around and have fun!

Section 3: A transition from the volcanic rock stratigraphy and fine-grained hypabyssal intrusions, into the underpinning plutonic rocks: A path down-section of the Northern fault-bounded Basin to the plutonic rocks of the Los Martires Pluton, Alisitos Arc, Baja California

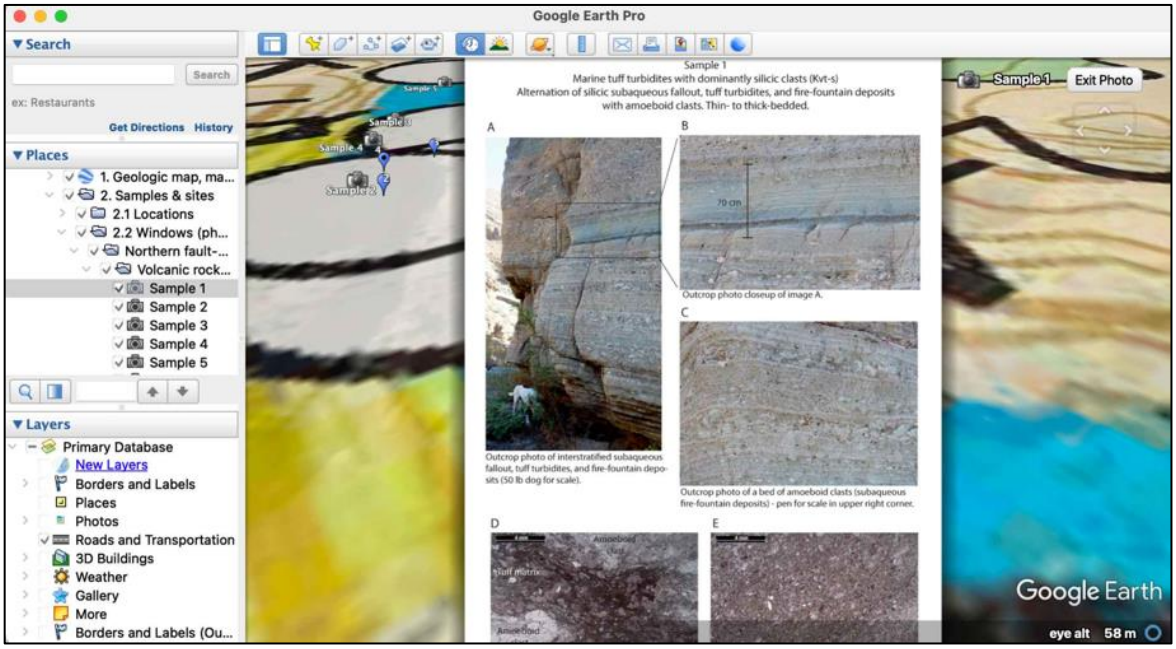
The transition from the volcanic rock stratigraphy and shallow hypabyssal intrusions, down into the underpinning plutonic rocks is best-exposed and most remarkable in the northern region of our study area. Here, we take you on a suggested transect to follow along on the 3D model - from entirely stratified volcanic rocks with fine-grained hypabyssal intrusions (i.e., cross-cutting dikes and concordant sills) through the transition zone of basal volcanic rocks engulfed by the intruding and underpinning pluton, and finally finish our transect in entirely plutonic rocks. Please note, this section simply provides a suggestion for sample/outcrops to visit, where full outcrop details are available within the outcrop '**window**', as well as in the **3D Alisitos Arc Model_outcrop summary table.xlsx**.

Stop 1 - Shallow volcanic rock stratigraphy and hypabyssal intrusions (sample 1 & 20)

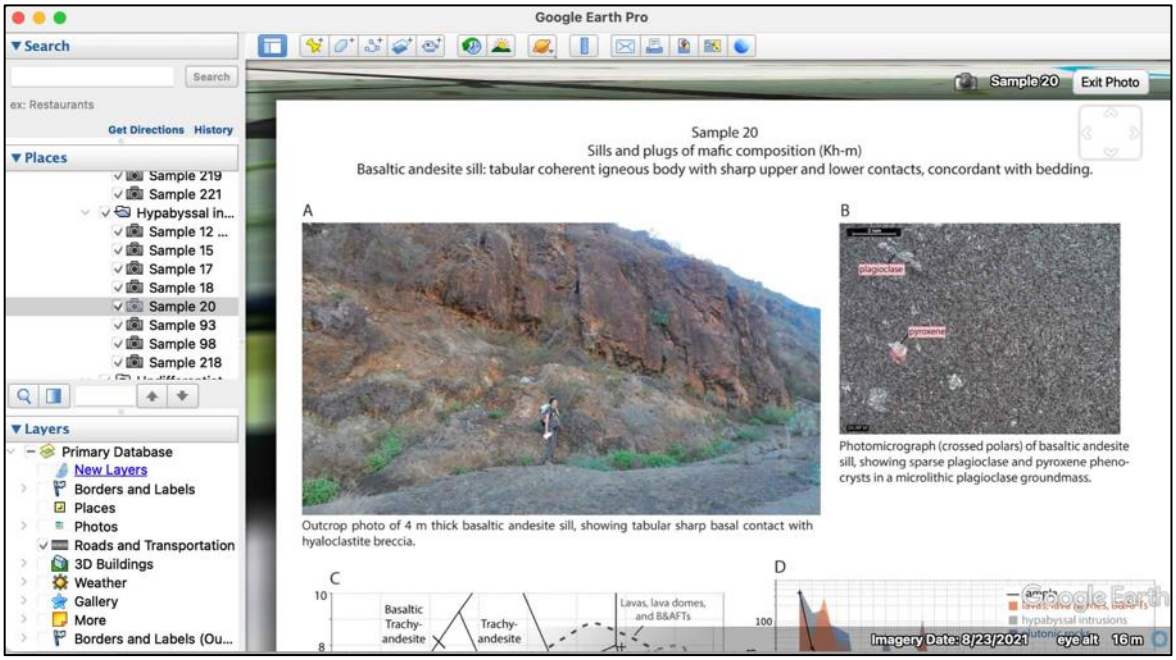
Here, we start our transition by presenting outcrops that represent some of the most shallow volcanic stratigraphy and hypabyssal intrusions of the northern fault-bounded basin. We see both compositional and depositional variation in the stratigraphic units (i.e., sample 1 - silicic marine tuff turbidites; sample 14 - basaltic andesite lava). Hypabyssal intrusions are mafic to mafic-intermediate in composition (i.e., sample 20 - a basaltic andesite sill) and are either concordant (sill) or discordant (dike or plug) with the surrounding stratigraphy.



Sample 1 displaying marine tuff turbidites in the shallow stratigraphy:

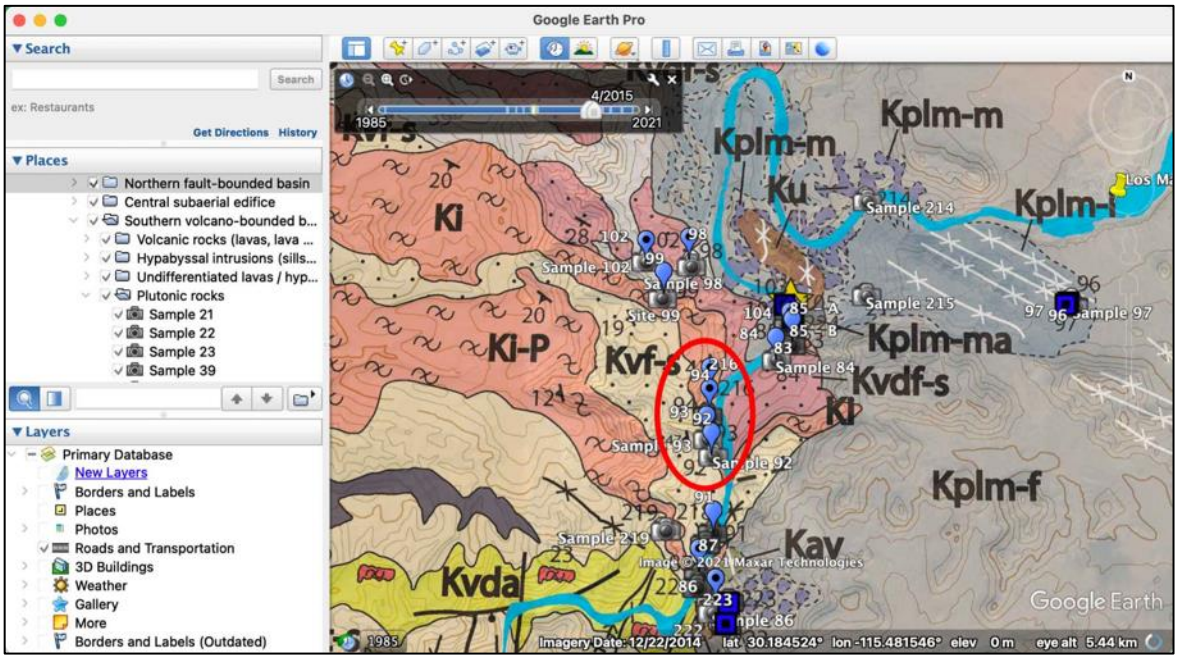


Sample 20 displaying a basaltic andesite sill concordant with underlying hyaloclastites:

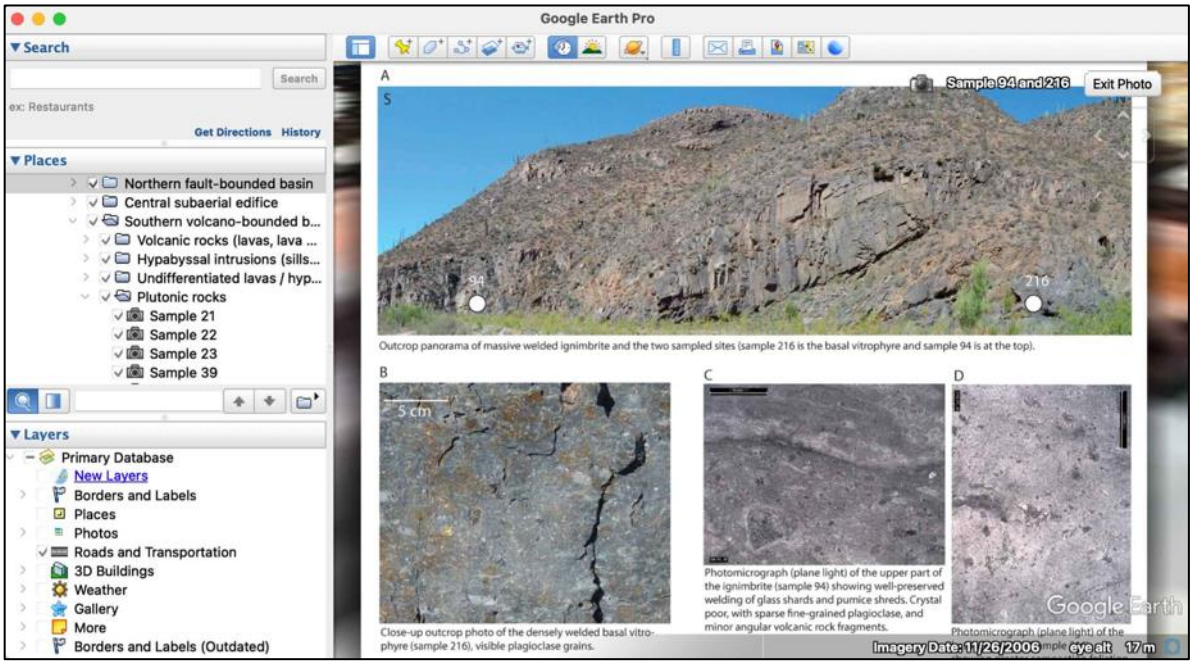


<u>Stop 2 - Ignimbrites and basal vitrophyres in the lower stratified volcanic rocks (samples 94 and 216)</u>

We move down-section within the volcanic pile where ignimbrites (sample 94) and associated basal vitrophyres (sample 216) are exposed along the western wall of the Los Martires Canyon.

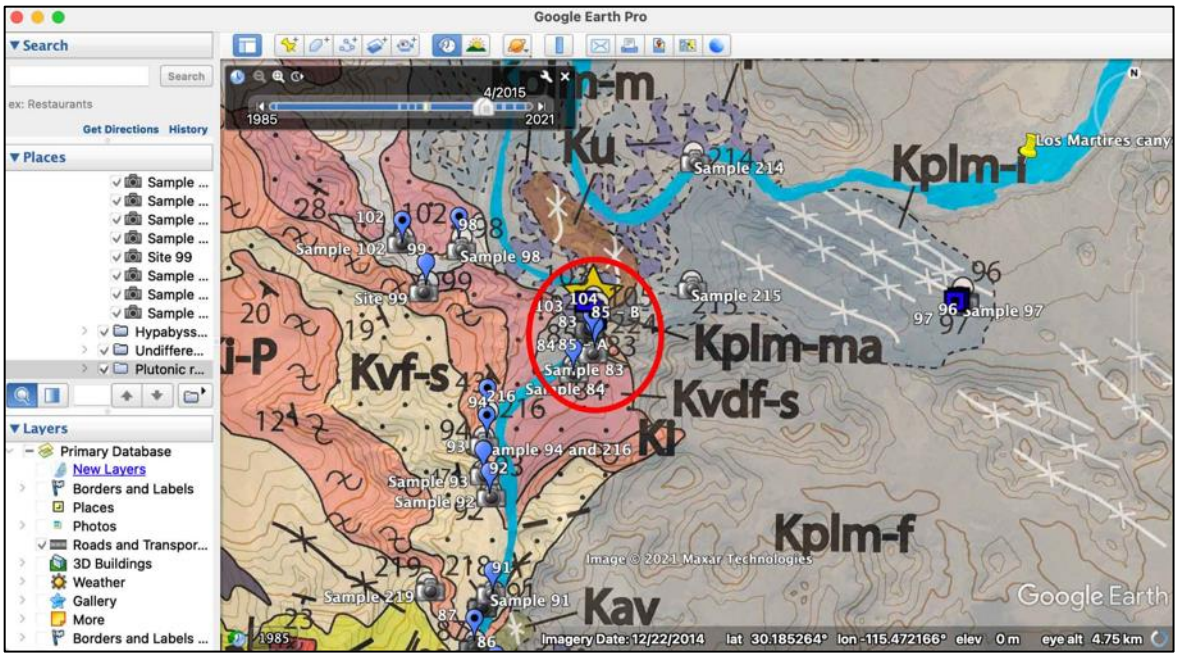


Sample 94 & 216 (combined - in window below) show a view of the exposed canyon wall of stratified volcanic deposits. As you walk north along the canyon, you travel down-section from massive welded ignimbrite (sample 94) into a basal vitrophyre (sample 216):

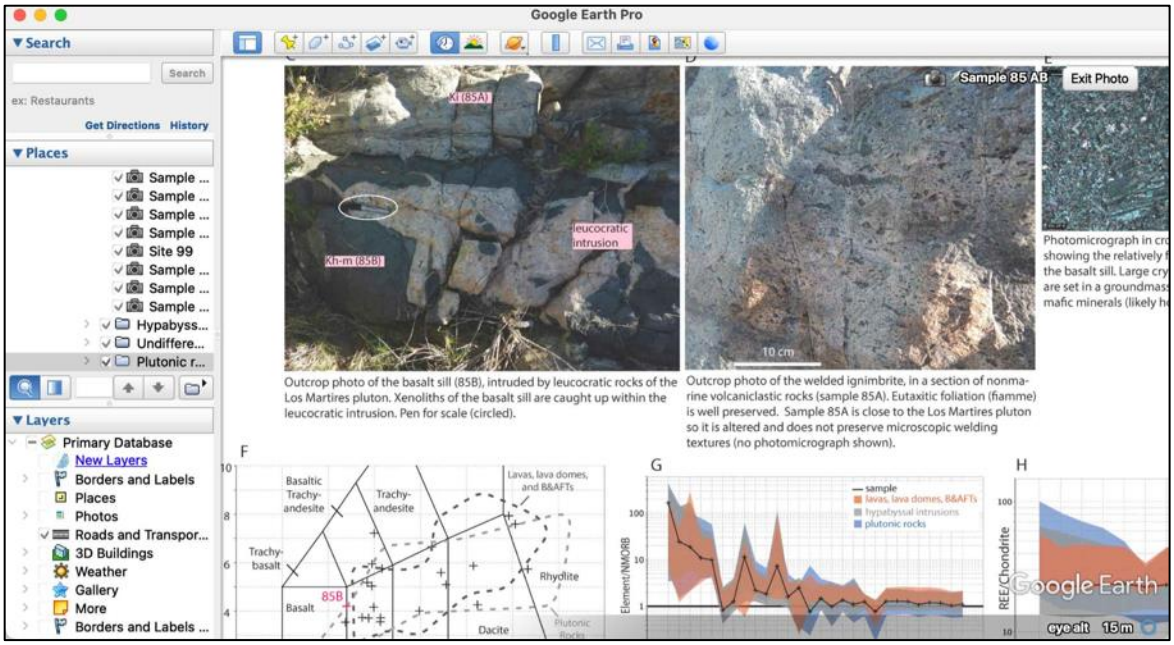


<u>Stop 3 - Volcanic rock to plutonic rock transition (samples 85A, 85B, 105, 103 and 104)</u>

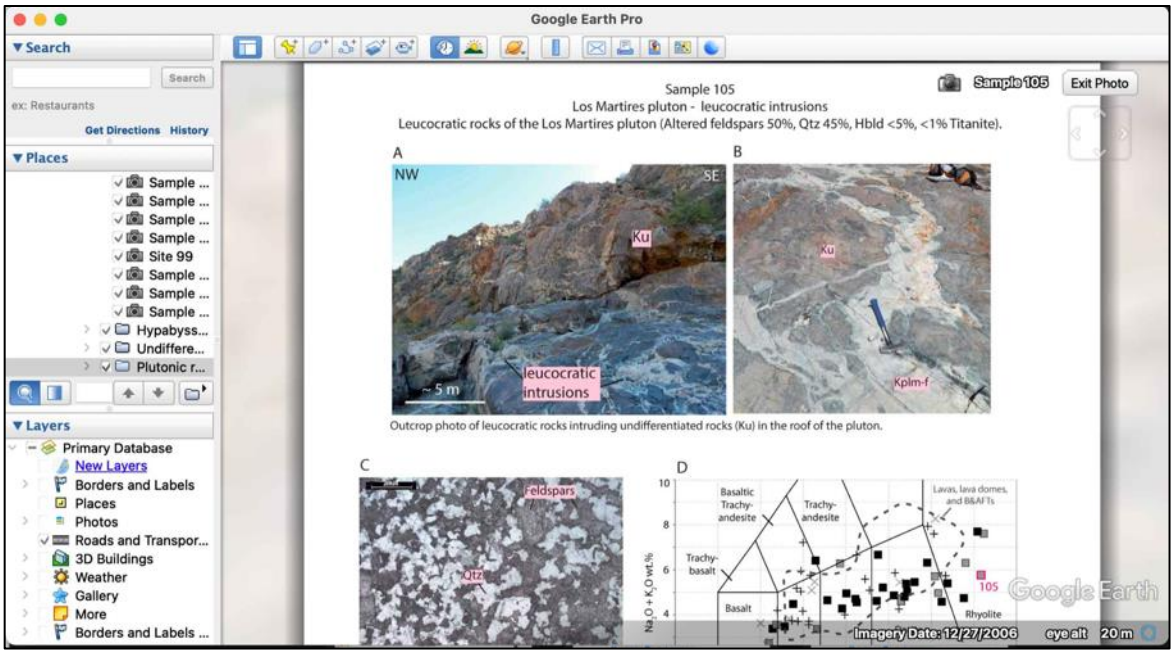
Further eastward, we move to where the Los Martires Canyon exposes the transition from entirely stratified volcanic rocks (85B - a welded ignimbrite), down-section into plutonic rocks that intrude and engulf volcanic rock stratigraphy (samples 105, 85A), and finally into entirely plutonic rocks exposed within the canyon bottom (samples 103, 104)



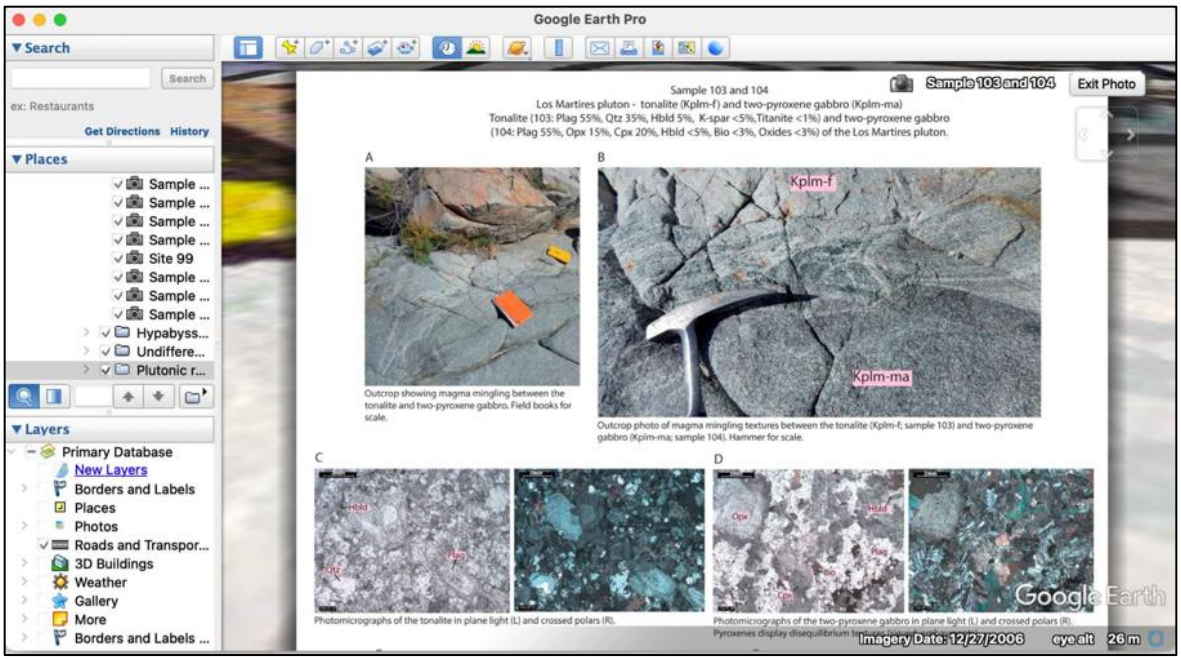
One of the lower-most stratigraphic units exposed in the northern fault-bounded basin includes a welded ignimbrite (85A) with a concordant mafic sill (85B), and coarse-grained leucocratic intrusions that intrude the sill. The approximate paleo-vertical distance of these coarse-grained leucocratic intrusions which intrude the basal volcanic stratigraphy down into entirely plutonic rocks occurs over ~150 m.



Further down-section (heading north) and exposed on the ~northeastern canyon wall, undifferentiated volcanic rocks are invaded by small (<m-scale) leucocratic intrusions. These volcanic rocks could not be discerned as a lava, sill, or dike within the field (hence classified as 'undifferentiated'), but are interpreted to represent the most basal volcanic stratigraphy of the northern fault-bounded basin. The composition of these leucocratic intrusions are some of the most felsic compositions of plutonic rocks sampled for geochemistry within the study area:

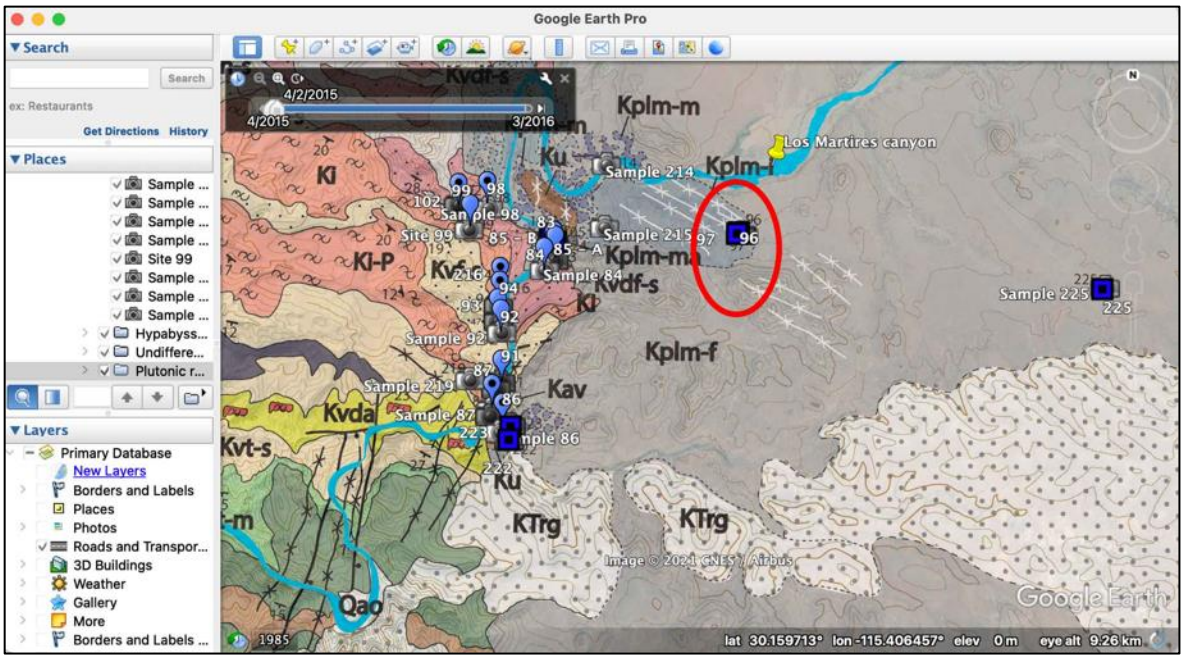


Immediately down-section of sample 105 within the canyon bottom, are well-exposed rocks that are entirely plutonic (coarse-grained) and display strong magma mingling textures between tonalite (sample 103) and gabbro (sample 104):

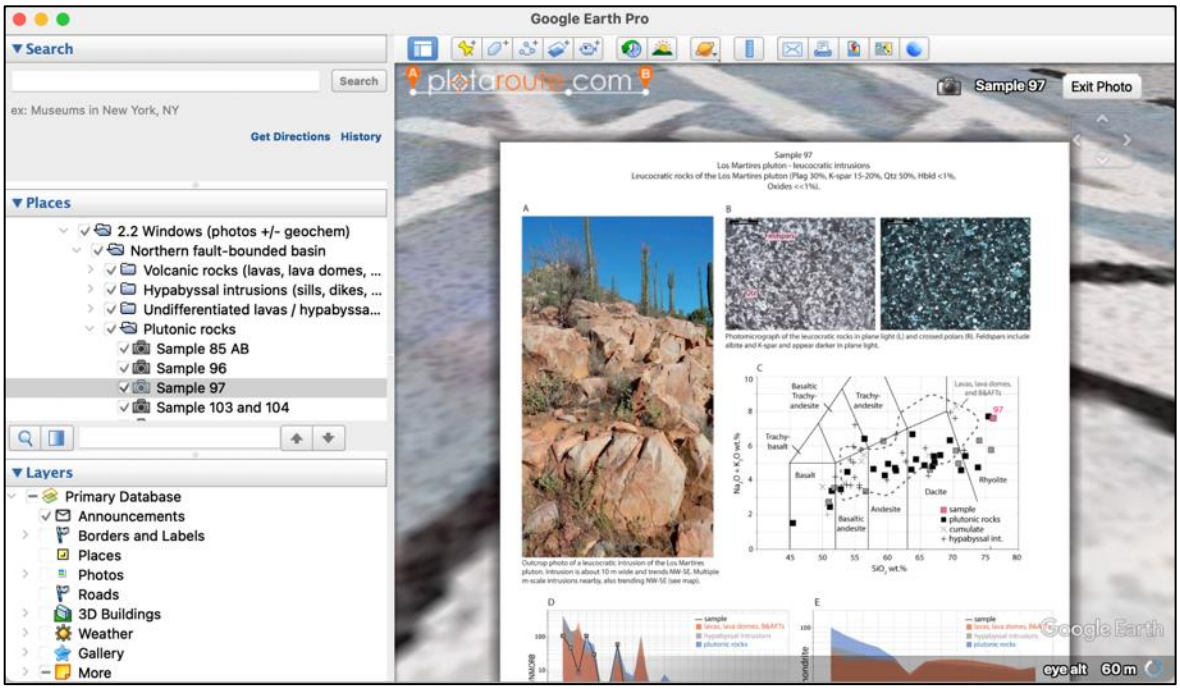


<u>Stop 4 - Late-stage leucocratic intrusions that intrude the main body of the pluton (sample 96A, 96B, and 97)</u>

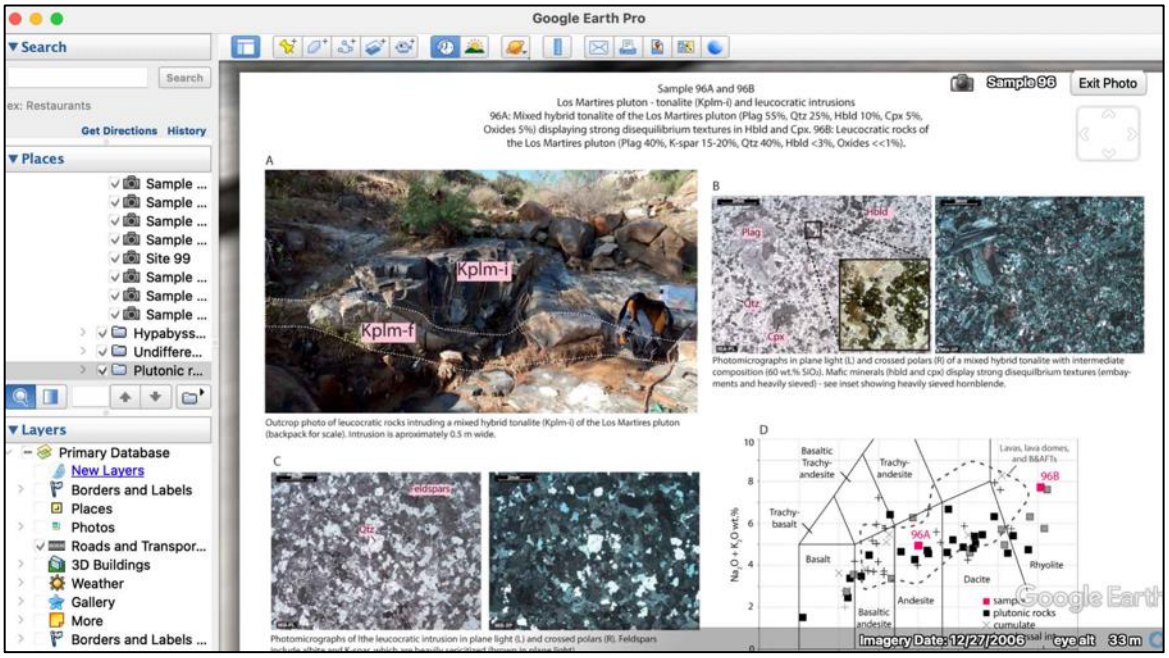
We again move eastward and down-section into the pluton, where we observe leucocratic intrusions (samples 96B and nearby 97) that intrude an intermediate phase of the Los Martires pluton (sample 96A).



The leucocratic intrusions generally strike NW-SE and in some cases are >10 m wide in thickness, and topographically form well-exposed and resistant ridges (sample 97):

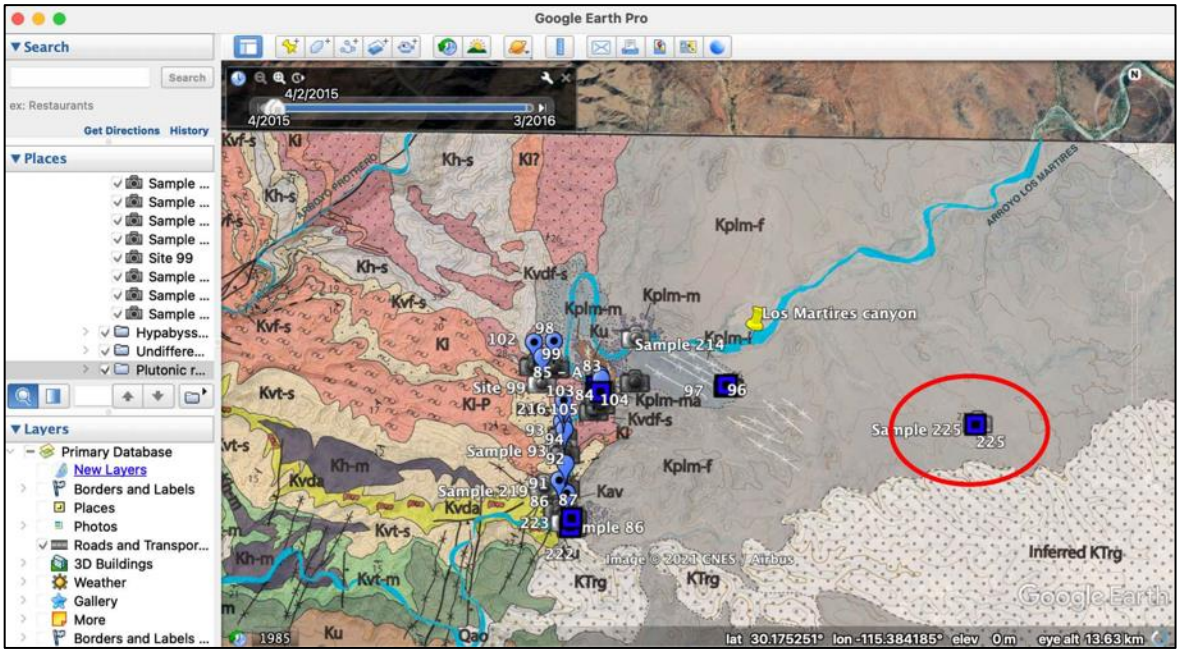


Here, a leucocratic intrusion (sample 96B) cross-cuts an intermediate phase described as a ‘mixed hybrid tonalite’ of the Los Martires pluton (sample 96A):

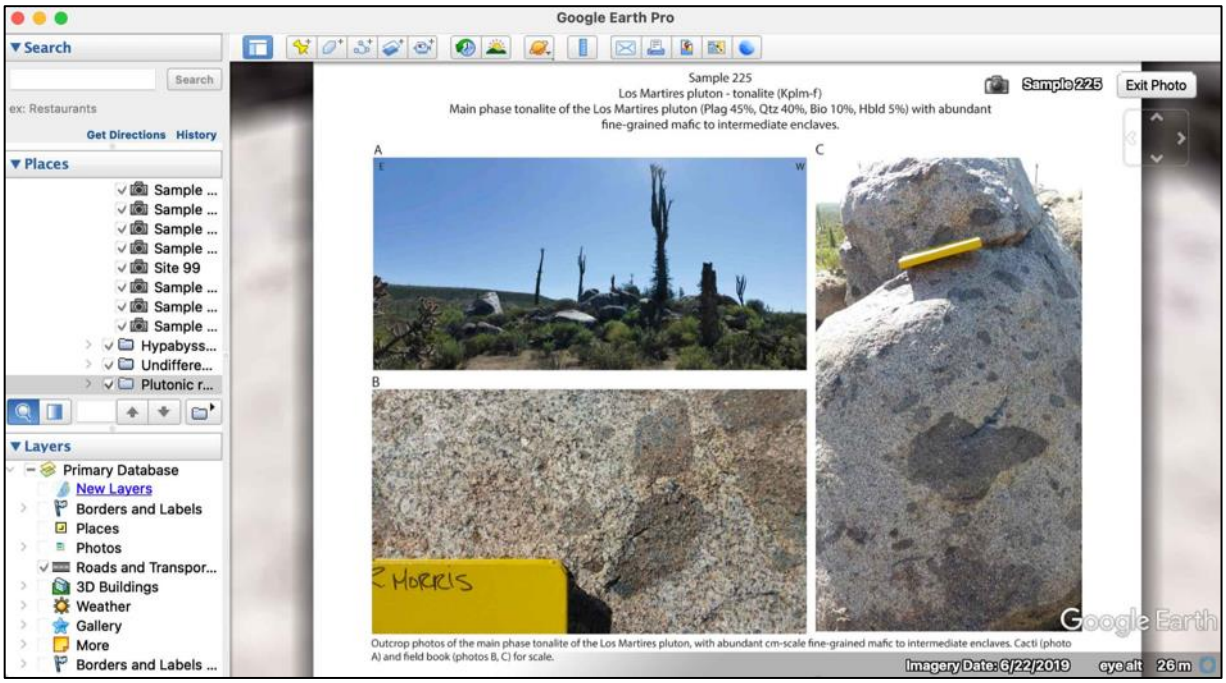


Stop 5 - The underpinning plutonic rocks (sample 225)

Finally, we end our transect by presenting an outcrop that represents what the main body of the Los Martires pluton looks like - by observing a sample collected within the interior region of the pluton (sample 225).



At sample 225, one can observe that Los Martires is dominantly a tonalite with abundant fine-grained mafic enclaves (basalt to basaltic andesite in composition and hornblende-bearing).



Other suggested volcanic rock to plutonic rock transitions to explore:

Within the NFBB: Samples 221 → 223 → 222
Within the CE: Samples 189 → 190 → 205 → 206
Within the SVBB: Samples 66AB → 66CDE; samples 71 → 70 → 69 → 68; and samples 60 → 61 → 62 → 64 → 63

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