Cryptotephra from an Archaeological Site at Pinnacle Point, South Africa

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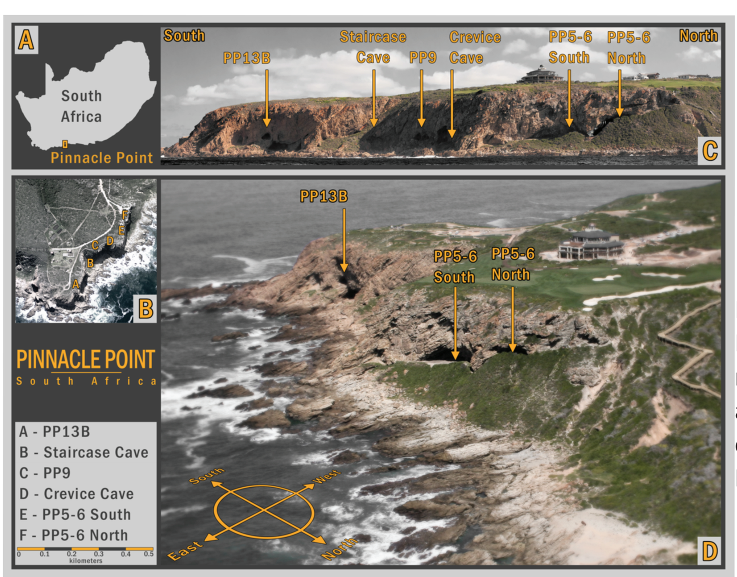
Abstract

Cryptotephra in the form of bubble-wall shards are present within late Middle Stone Age (MSA) sediment in rock shelter PP5-6 at Pinnacle Point, South Africa. The cryptotephra are found in two sediment units, the Shelly Ashy Dark Brown Sand (SADBS) and the Ashy Light Brown Sand (ALBS), with weighted mean Optically Stimulated Luminescence (OSL) age estimates of 70.6 +/- 2.3 ka to 71.1 +/- 2.3 ka (Brown et al., 2012). The cryptotephra is rhyolitic in composition and does not match geochemically with any 70 to 80 ka African or Antarctic eruptions. The closest match for major elements is the Youngest Toba Tephra (YTT). The YTT super-eruption 73.88 +/- 0.32 ka spread ash from the South China Sea to India and the Indian Ocean (Lane et al., 2013). The most distal YTT deposit and the first documentation of the YTT in Africa is in Lake Malawi, 7,300 km from Toba (Lane et al., 2013). The YTT provides a widespread isochronous marker with a well-defined age that can be used to constrain ages obtained through different mean and link stratigraphic units from multiple regions. If the Pinnacle Point cryptotephra are from Toba, the tephra would have traveled almost 9000 km from the source in Sumatra, Indoesia and would be the first documented YTT deposit in South Africa. Futhermore, it would be the mostl distal YTT deposit to date and could help constrain the OSL ages of the sediment it is found in. If found in other MSA sites in South Africa, this cryptotephra could be used to linek the stratigraphic units and archaeological
finds.

Location



Study area: Pinnacle Point rock shelter 5-6 North, Mosselbaai (Western Cape), South Africa.

The rock shelter is located in the quartzite cliffs of the Table Mountain Group (TMG) and is part of a series of caves along the coast.

Figure 1: Location map and aerial image of Pinnacle Point.

Figure 2: Outside view of PP5-6 North. The tent to the lower left corner is the sieve station and the Long Section is under the green tarp.

Background

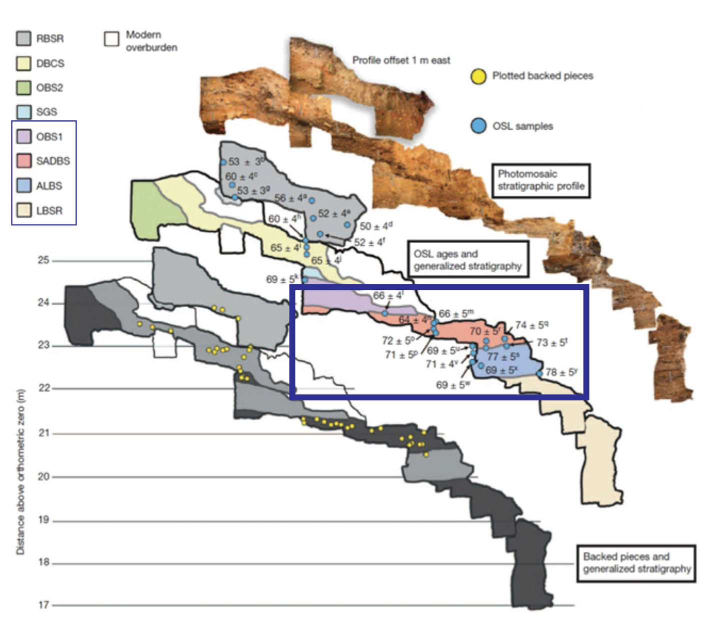


Figure 3: Stratigraphic section called the Long Section at PP5-6 North. The blue box indicateswhere samples were collected.

The caves at Pinnacle Point contain sediment from 130 ka to 50 ka and span several important environmental and archaeological transitions.

At PP5-6 North, sediment ranges from 90 ka to 50 ka. The stratigraphic section is called the Long Section and is a 30 meter sediment cone (Brown et al., 2012). Archaeological findings include hearth features, dense shelly layers, animal bone, and stone tools from materials such as quartzite, silcrete, chalcedony, and chert (Brown et al., 2012).

Around 70 ka, in the SADBS (Shelly Ashy Dark Brown Sand) and ALBS (Ashy Light Brown Sand), there is a shift from a greater abundance of quartzite tools to silcrete, mainly heat-treated, tools (Brown et al., 2012).

In these sediment layers, glass shards (cryptotephra) have been found in minor quantities as well as opal-like material. The purpose of this project is to use the glass shards to test the OSL age estimates along the quartzite-silcrete transition. If the tephrochronology correlates with the OSL age estimates, it would corroborate the OSL age estimates given for the HP (Howieson's Poort) and SB (Still Bay) lithic industries by Zenobia Jacobs (see Jacobs et al., 2008).

In 2012, sediment was collected from the SADBS and ALBS units. This is where the original shards were found. Subsequent sampling in 2013 and 2014 took place in the OBS1 (above SADBS) and the top meter of the LBSR (below ALBS).

Methods

In the Field

- Collect samples at 1 cm intervals
- Record location with total station
- Place photo chits around sample site
- Photograph sequence

Figure 4: 2012 sampling trench.

In the Lab

- Place 1 g of sample into 50 mL tubes
- Acid digestion with 10 % HCl
- Wet sieving at 80 and 20 microns
- Heavy liquid separartion (LMT)
- Make reference slides
- Count shards
- Make shard frequency diagram
- Repeat separation process
- Shard picking using micro-manipulator
- Mount on epoxy round
- Grind and polish
- Analyze with microprobe

Shard Geochemisty

Sample	48	12 (2)	49 (3)	YTT Malawi	YTT India	YTT Malaysia
SiO2	71.52	76.01	76.69	77.24	77.24	77.7
Al2O3	15.15	13.05	12.09	12.41	12.54	12.37
FeO	1.34	0.82	1.51	0.84	0.85	0.93
MgO	0.16	0.03	0.06	0.05	0.05	0.05
MnO	0.04	0.06	0.04	0.07	0.07	0.05
CaO	0.74	0.76	0.73	0.77	0.78	0.81
Na2O	4.6	3.45	2.64	2.95	3.1	2.81
K2O	5.92	5.35	5.77	5.61	5.2	5.06
TiO2	0.27	0.04	0.17	0.05	0.06	0.04

Table 1: Pinnacle Point shard geochemistry compared to YTT distal deposits from Lake Malawi (Lane et al., 2013), India (Smith et al., 2011), and Malaysia. All data is normalized to 100 %.

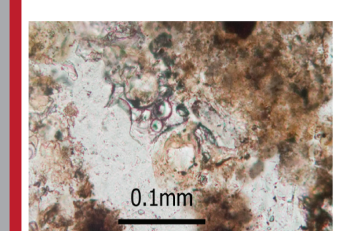


Figure 5: Original shards found by Panagiotis Karkanas

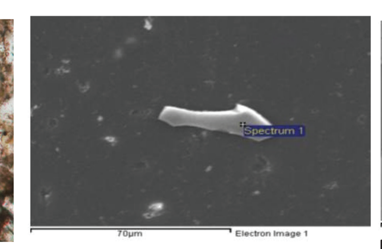


Figure 6: SEM backscatter image of Shard 97, the first shard analyzed

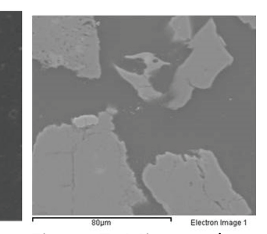


Figure 7: Microprobe image of Shard 48

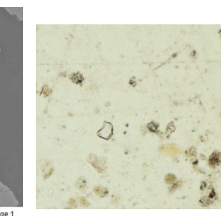
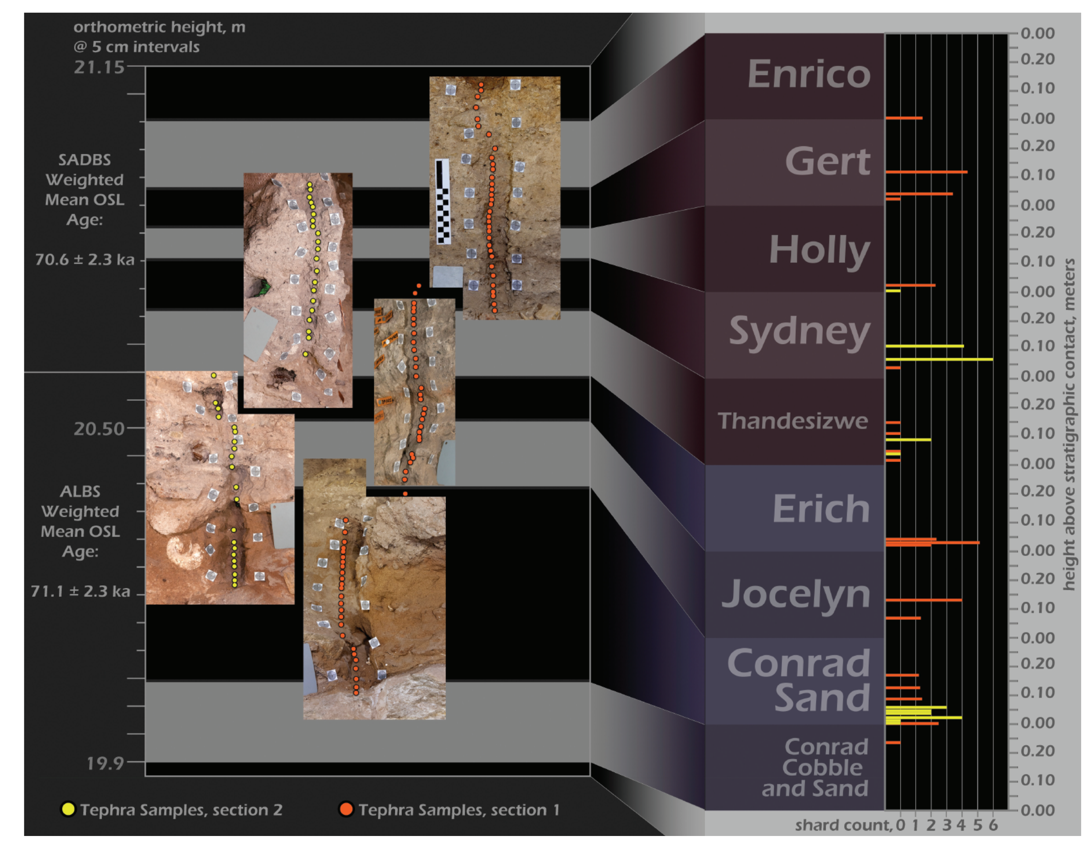


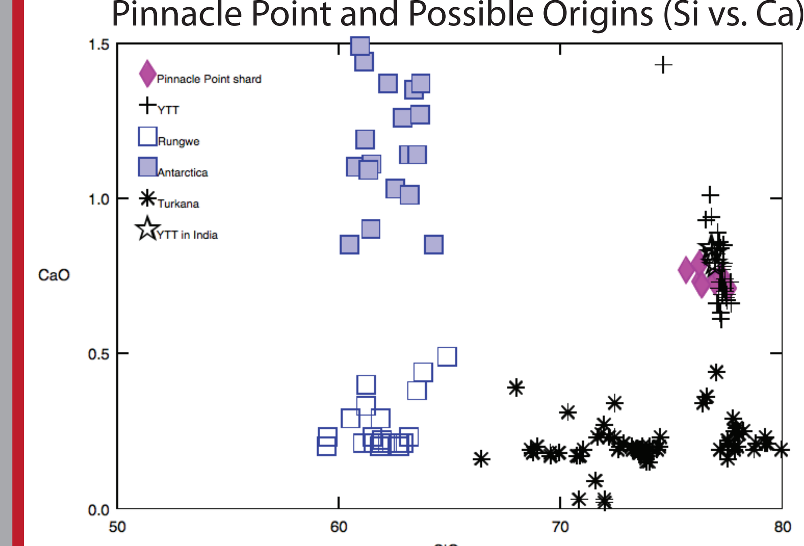
Figure 8: Shard 12 (2) in plane polarized light.

Shard Distribution



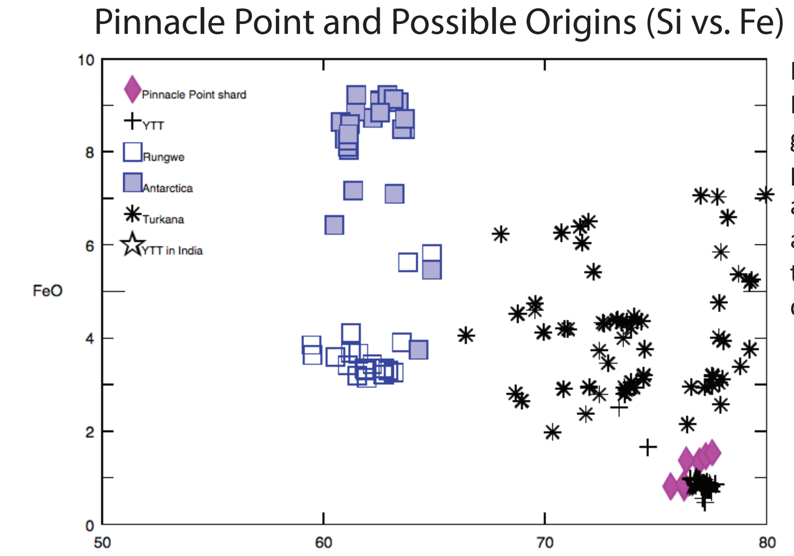
Comparison Plots

Pinnacle Point and Possible Origins (Si vs. Ca)



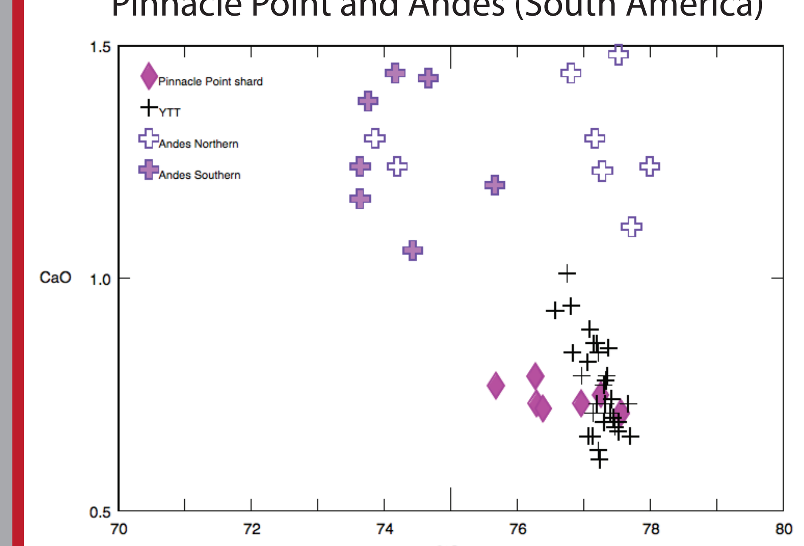
Plot 1: Si vs. Ca plot showing the comparison between the Pinnacle Point cryptotephra and volcanic products from possible sources in Antarctica, Africa, and Indonesia 50-90 ka. None of the African or Antarctic sources appear to match the Pinnacle Point cryptotephra.

Pinnacle Point and Possible Origins (Si vs. Fe)



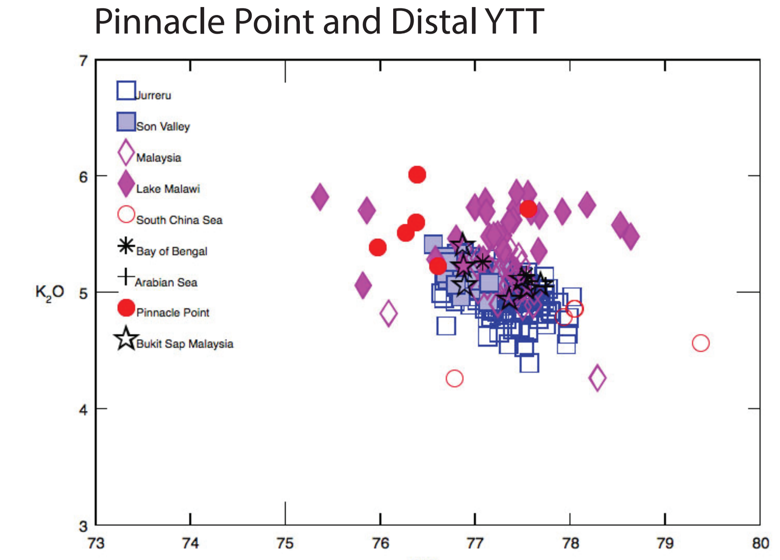
Plot 2: Si vs. Fe plot of the Pinnacle Point cryptotephra geochemistry compared to possible sources. The Antarctic and African sources all have higher Fe values than the Pinnacle Point cryptotephra.

Pinnacle Point and Andes (South America)



Plot 3: Si vs. Ca comparison plot of the Pinnacle Point geochemistry and the Andes. Ash from the Andes has sometimes been known to cross the Atlantic and reach Africa, making it a possible source. However, the geochemistry does not match.

Pinnacle Point and Distal YTT



Plot 4: Si vs. K plot comparing the geochemistry of the Pinnacle Point cryptotephra and distal YTT (Youngest Toba Tephra) deposits. The Pinnacle Point and Lake Malawi shards are slightly higher in K than the other deposits. So far, the YTT is the best match for the Pinnacle Point cryptotephra during the time period.

Opal-Like Material

Sample	36 (3)	36 (1)	36 (2)	49 (1)
SiO2	82.84	79.87	81.94	85.85
Al2O3	1.7	2.27	0.03	0.01
FeO	0.32	0.07	0.14	0
MgO	0.25	0.01	0.18	0.03
MnO	0.01	0.04	0.06	0.01
CaO	0.71	0.08	0.52	0.07
Na2O	0.22	3.67	0.35	0.73
K2O	0.51	0.08	0.24	0.43
TiO2	0.07	0.03	0.03	0.15
P2O5	0.01	0.04	0	0.02
Cl	0.05	0.1	0.12	0.06
F	0	0.4	0	0.02
Total	86.69	86.66	83.61	87.38

Table 2: Geochemistry of "pseudo-shards". These were originally identified as shards but the geochemistry is similar to opal. Are they altered shards or endemic to the rock shelter? Conditions should not be right in the rock shelter for opal formation.

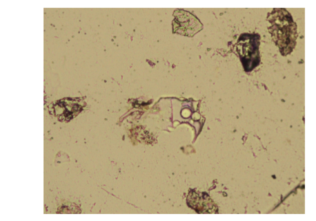


Figure 8: Petrographic image of analyzed opal-like material. Several pieces are overlaping, creating the appearance of cuspate margins and bubbles.

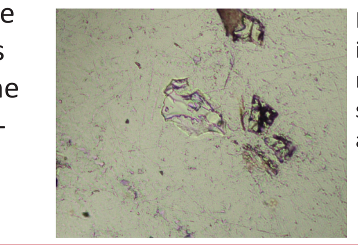


Figure 9: Petrographic image of analyzed opal material found in the same slide as the image above.

Conclusions

Cryptotephra is present in minor quantities within the sediment units SADBS and ALBS in PP5-6 North.
The geochemistry and OSL age estimates correlate well with the YTT (Youngest Toba Tuff).
If the shards are from Toba, it will mark the most distal YTT deposit, almost 9000 km from the source in Sumatra, Indonesia.
Cryptotephra can be found within sand dune deposits at archaeological sites, as demonstrated here and in Housley et al., 2014.

Questions

Is the amount of glass shards present (less than 10 per centimeter) enough to test the OSL age estimates?

Is the opal-like material an alteration product of the shards or is it in the quartzite?

What is the origin of these shards if not Toba?

Future Work

Over the next few months, the rest of the original 130 samples from the SADBS and ALBS will be processed and analyzed.
If the shards appear to be randomly distributed in the section, the OBS1 and LBSR samples will be processed to find the first and last appearance of the shards.

Acknowledgements

We thank the MAPCRM staff for their assistance, the Dias Museum for field facilities, and SAHRA and HWC for permits. This research was funded by the National Science Foundation (# BCS-9912465, BCS-0130713, BSC-0524087, and BCS-1138073 to Marean), the Hyde Family Foundation, the Institute of Human Origins (IHO), and the Late Lessons in Early History program at Arizona State University.

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