Glacial Chronologies Along the Eastern Sierra Nevada From Be-10 Surface Exposure Dating

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Research Objectives

• Construct a paleoclimate record spanning the past >100 ky using Be-10 in quartz

• Compare timing to LGM and penultimate glacial chronologies globally
Motivation

• Understanding of global paleoclimate variations includes knowledge of the age, duration, and extent of alpine glaciations around the world

• TCN surface exposure dating allows more accurate, high-resolution chronologies in the <1 ky-200 ky temporal window
Methods

• geomorphic mapping of glacial deposits

• Be-10 surface exposure dating of Quaternary glacial and alluvial deposits

• compare ages to other regional and/or global paleoclimate records
KEY

- Basin and Range province = dark gray
- CNSZ = central Nevada seismic zone
- ECSZ (eastern California shear zone)
- ISB = intermountain seismic belt
- WLB = Walker Lane belt in light grey

Source: Glazner et al., 2005
Faults in red from CDMG 1:250,000 Walker Lake sheet by Konig, 1963
Sonora Pass Study Area
Mapping modified after Clark, 1967
19.0 +/- 0.3 (1 sigma) ka (n=6)

SJTIR
19.5 +/- 1.2 ka (n=8)
Mapping modified after Clark, 1967.
19.9 +/- 2.7 ka (n=8)
Tahoe Outwash Terrace Depth Profile

3 component exponential production profile (spallation, mu-minus capture, fast muons)

Exposure Age (no erosion): 142 ka

Model code courtesy of Regis Braucher
Surface exposure ages for glacial deposits (boxes)

Light blue = LLGM

Dark blue = Penultimate

Sonora Pass Study Area

Mapping modified after Clark, 1967
Faults in red from CDMG 1:250,000 Walker Lake sheet by Konig, 1963
Buckeye Creek Outwash Terraces
$136 \pm 10 \text{ ka (n=6)}$
19.5 +/- 0.7 ka (n=4)
Bridgeport Basin Study Area

Surface exposure ages for glacial deposits (boxes)

Light blue = LLGM

Dark blue = Penultimate
Faults in red from CDMG 1:250,000 Walker Lake sheet by Konig, 1963
Mono Basin Study Area: Lundy Canyon

View to SW

Sherwin (?) moraine crest
Mono Basin (?) moraine crest
Triangular facet

Tioga moraine crest

View to W

Offset Tioga moraine crest
Fresh fault scarps

Offset Tioga outwash terrace tread

Terminology based on mapping by Bursik, 1989
17.2 +/- 0.5 ka (n=5)
Bridgeport & Mono Basin Study Areas

Surface exposure ages for glacial deposits (boxes)

Light blue = LLGM and deglaciation

Dark blue = Penultimate
Comparison to Proxy Records
LLGM

19.5 +/- 1.6 ka (n=26)
Deglaciation

17.2 +/- 0.5 ka (n=5)
Penultimate

136 +/- 10 ka (n=6)

142 ka
SPECSTACK = Imbrie, Martinson, et al., Benthic 18O stack

Global Marine Proxy

Source: J. Imbrie, A. McIntyre, and A. C. Mix, in 'Climate and Geosciences, A Challenge for Science and Society in the 21st Century'; McIntyre et al., 1989
Antarctic Ice Core Proxy

Source: Jouzel, J., et al. 2004
Greenland Ice Core Proxy

Source: Grootes et al., 1997; Stuiver et al., 1995; Meese et al. 1994; Steig et al. 1994; Grootes et al., 1993
Greenland Ice Core Proxy

Source: Grootes et al., 1997; Stuiver et al., 1995; Meese et al. 1994; Steig et al. 1994; Grootes et al., 1993
delta 180 DATA FOR DEVILS HOLE CORE DH-11

NH Speleothem Proxy

Summary
Conclusions

• LLGM at 19.5 +/- 1.6 ka (n=26), deglaciation at 17.2 +/- 0.5 (n=5)
  – Correlates well with Dome C and SPECMAP proxy records
  – May anticorrelate with GISP2

• Penultimate glaciation (MIS 6-5E transition) at 137 +/- 9 ka (n=7), possibly 142 ka
  – Correlates well with Dome C and SPECMAP
  – May anticorrelate with Devils Hole
Implications

• Interhemispheric patterns (e.g. Schaefer et al., 2006; Shulmeister et al., 2006)
  – Faster response in NH alpine systems?

• Orbital cycles (e.g. Thompson & Goldstein, 2005)
  – Resolution of 100 ky orbital signal using TCN’s?

• Tenaya, Younger Tahoe, Mono Basin (e.g. Phillips et al., 1990) missing or not prominent in dataset

• Surface exposure dating of outwash surfaces for >100 ka glacial deposits
Holocene Moraines

- Recent advances at CAMS-LLNL demonstrate feasibility

- Be-10 dating of Holocene deposits when radiocarbon methods limited by plateaus in calibration curve (Guilderson et al., 2005) (e.g. Little Ice Age)
Thank you

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Surface exposure ages for mid-latitude inner LGM glacial deposits

Solid line = Mean of all mean ages (~17.2 ky)

Dashed line = Mean of all oldest ages (~19 ky)

Source: Schaefer et al., 2006
Surface exposure ages for tropical LGM glacial deposits

Source (left): Smith et al., 2005

Source (right): Blard et al., 2007
Gaussian probabilities of C-14 ages for 2340 (left) and 2460 (right) radiocarbon years B.P. with calibration curve.

2340 = *decadal* age range

2460 = *several century* age range

Source (left): Guilderson et al., 2005