# **Methods for Dating Quaternary Surficial Materials**

	M. Sowers <sup>1</sup> Type of Method	l, Jay Stratton Noller <sup>2</sup> , and Willia <sup>c</sup> Method S	am R. I	<10% Resc 10 <sup>2</sup> 10 <sup>3</sup>		) <sup>a,b</sup>	Error and Reporting Standards		Basis of Method	APPICATIO	15-20 Language and the second	AN CONTRACT	e crent a creation of the crea	5 S <sup>15</sup> S <sup>15</sup> S <sup>16</sup> S <sup>16</sup>
Result	Method			Ag	e range (yrs)	I I		Time range varies with availability of local ring-width		3858/42	- 88 - 34		<u> </u>	1 6 C V .
	eal	1. Dendrochronology					(see ref )	data for cross dating	Aging of live trees, or correlating nng-width chrono to other trees Counting seasonal sediment layers back from the					•
	Sidereal	2. Varve chronology					(see ref )		present, or correlating a sequence with a continu chronology				• 🗶 🛞	
	_~ ا	3. Sclerochronology	11				(see ref )		Counting annual growth bands in coral and moli	usks				
		4. Radiocarbon	1				1σ	Total standard error combines 1 $\sigma$ analytical error and 1 $\sigma$ calibraton error (see ref )	Radioactive decay of atmospheric <sup>14</sup> C to <sup>14</sup> N in organic tissue or carbonates.			••		• • • • •
		5. <sup>10</sup> Be	II				f					88		
		<sup>26</sup> Al 36ct Cosmogenic	Ш				f		Formation, accumulation, and decay of cosmogenic nuclides in rocks or soils exposed to cosmic radiation			ě 8		
	l H		II		<u>.</u>		f	Range may be younger at high elevations or high latitudes, older at low elevations or low latitudes		nic on		8 A.	\$ 2	
	Pic -AG	<sup>3</sup> He	II			772	f	Range shown is for olivine samples				Z 2.		
	llCAL-AC Isotopic	14C	U.				f∫	ļ					88	
	IUMERICAL-AGE Isotopic	6. K-Ar, Ar-Ar	1				2σ	Range assumes high-K materials For young materials (<1ma) the Ar-Ar method may be more accurate than K-Ar	Radioactive decay of <sup>40</sup> K trapped in K-bearing sile minerals during crystallization, to <sup>40</sup> Ar	cate		8 X .	•	
	<u>N</u>	7. U-series: <sup>234</sup> U– <sup>230</sup> Th	I				1 σ or 2 σ	Resolution shown is for pure sedimentary carbonates and	Radioactive decay of uranium and daughter nucli	des		ו*	• • •	• • • •
NE-AGE	Z I	<sup>235</sup> U_ <sup>231</sup> Pa	I				1σ or 2σ ∫	coral Error is often greater for impure carbonates Mass spectrographic analysis can improve precision	in chemical and biogenic sedimentary minerals		22	. • • •	• • •	• • • •
		8. <sup>210</sup> Pb	I.				1σ	Resolution improved when used with <sup>137</sup> Cs	Radioactive decay of <sup>210</sup> Pb to <sup>206</sup> Pb		22	8 • 8 (	• • • 🖉	•
		9. U–Pb, Th–Pb	0					Age resolution is a function of the $\Delta$ <sup>238</sup> U/ <sup>204</sup> Pb of sample suite, range shown is calculated with $\Delta$ <sup>238</sup> U/ <sup>204</sup> Pb=100.	Using normalized Pb isotopes to detect small enno of radiogenic lead from U and Th decay	hments			<u> </u>	
	.y	10. Fission-track: zircon & glass	1				2σ	Dating volcanics with zircon or volcanic glass	Accumulation of damage trails (fission tracks) from (	natural		88	- X - X	•
	gen	apatite	I				2σ	Dating unroofing with apatite	Accumulation of damage trails (fission tracks) from i fission decay of trace <sup>238</sup> U in zircon, apatite, or gl	ass				
	Radiogenic	11. Luminescence	I.		1		1σ	Typical resolution is 5-20%. Time range and resolution vary strongly with natural radiation level and mineralogy	Accumulation of electrons in crystal lattice defects silicate minerals, due to natural radiation	s of		94 - 98, ``		•
	, w	12. Electron-spin resonance	I.			772	1σ	Assuming average level of radioactivity in the host rock	Accumulation of electrical charges in crystal lattic defects of silicate minerals, due to natural radiatio	e in			alan bara	• •
	ي ھر	13. Amino-acid racemization	I				(see ref.)	Range is for mollusks from midiatitudes, racemization rates increase with temperature	Racemization of L-amino acids to D-amino acids i fossil organic material	n		à à	V X	•
		14. Obsidian hydration	I			2273	(see ref.)	Range depends on temperature and obsidian chemistry	Increase in thickness of hydration rind on obsidial surface	n 🖉			•	•
1 I E	Chemical Biologic	15. Lichenometry	П		a		(see ref )	Time range varies with environmental conditions	Growth of lichen on freshly exposed rock surfaces					
E-AGE	_ بن پن	16. Soil-profile development	1				(see ref.)	Resolution and time range depend on the availability of a dated chronosequence for calibration	Systematic changes in soil properties due to weather additions, losses, and redistribution of material	nng,				
<u> </u> <u> </u> <u> </u> <u> </u> <u> </u>	lorp	17. Rock and mineral weathering	I.				(see ref.)	Time range varies with weathering parameter and climate Resolution may be improved with local calibration	Systematic alteration of rocks and minerals due to exposure to weathering processes					
	Geomorphic	18. Scarp morphology	Ш				(see ref )	Uncertainty may be < 50% under favorable conditions For high scarps that change slowly, range may extend to 0.5 Ma	Progressive change in scarp profile due to surface processes, from steep and angular to gentle and rour	nded			•	
	<u> </u>	19. Paleomagnetism:											<u>z</u>	
		Secular variation	1		ga <sup>9</sup>		(see ref.)	Resolution depends on the ability to correlate to master	Secular variation of the earth's magnetic field recorded in magnetic minerals		<b>.</b>	2 4.		
		Reversal stratigraphy	1				(see ref )	Assumes either independent age control or several magnetic polarity zones are available so that correlations	Reversal of the earth's magnetic field recorded in		- SER 🖨 SREE 🖨 S	ě ¥.		•
	5	20. Tephrochronology	i i				(see ref.)	to the Magnetic Polarity Time Scale can be made	magnetic minerals Recognition of individual tephra by their unique				<b>a a</b>	
	Correlation	21. Paleontology:	-					Resolution depends on the resolution of dating methods used to establish reference stratigraphy (K-Ar, Ar-Ar, luminescence, <sup>14</sup> C, fission track)	properties, and correlation of these to a dated stratigraphy					. 🛛 🖉 .
	orre	Evolution of microtine rodents	I.		i ¦		(see ref )		Progressive evolution of microtine rodents				22	
	Ŭ.	Marine zoogeography					(see ref )	Time range may be extended if a chronology is available in that range. Resolution is improved if used with another	Climatically induced zoogeographic range shifts o	of and a second s			28	
		22. Climatic correlations		י וו דע דע דע דע רע וו דע דע דע דע דע			(see ref )	In that range Resolution is improved if used with another dating method such as amino-acid racemation Resolution is highly dependent on the ability to correlate	marine invertebrates Correlation of landforms and deposits to global clin			8.8.	X X	
			0		ച്ചായത്തെങ്ങള്ള്ള് —	i i	(366 161)	to a specific climate change Additional correlations may sometimes be made at extreme ends of range	changes of known age		2 - 2	8 8 1	\$\$`\$\$`	

Plate 1. Methods for dating Quaternary surficial materials, in Noller, J.S., Sowers, J.M., and Lettis, W.R., 2000, Quaternary Geochronology: Methods and Applications. Copyright 2000 by the American Geophysical Union

Please note: This chart summarizes the more well known, widely used, or most promising new methods for dating Quatemary surficial matenals as of 1999. It is not intended to be a complete list of these methods

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#### Status:

- I Well-Established
- II Experimental, approaching established

Notes.

Notes, <sup>a</sup> Under optimum conditions where the assumptions of the method are met and the sample is of high quality. See references for further discussion. <sup>b</sup>The resolution of correlabilitated-age and calibrated-age methods (#11-24) is dependent on the resolution of the dating methods that establish the chronology used for calibration or correlation. The resolution of any of these methods can be improved if additional independent age constraints are available

<sup>c</sup> Classification of methods from Coleman, S, and Pierce, K, 1999, Classification of Quaternary Geochronologic Methods, in this volume

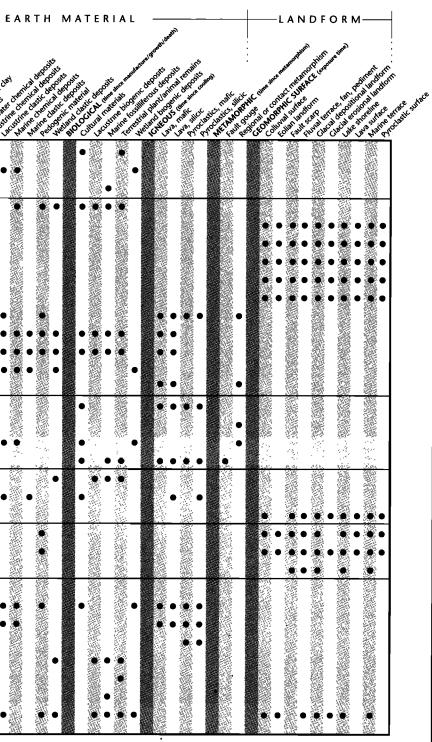
<sup>d</sup> Applications shown for each method are those considered typical. Under special conditions, or in certain geologic contexts, additional applications may be possible

#### e Range extends beyond time scales shown

f Resolution includes both  $1\sigma$  analytical error of <5%, and geologic uncertainties gBroken bar indicates that the method may not be continuously applicable through the time range shown, due to either lack of reference stratigraphies for that time range, or non-uniqueness of correlations.

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- References (by method number):
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