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CRITICAL EVALUATION OF RADIOMETRIC AGES USED FOR TRACKING HOTSPOTS IN THE PACIFIC OCEAN

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For tracking hotspot volcanism, precise and accurate (better than ±5%) ages are a prerequisite. Unfortunately, the literature has become "overloaded" with "ages" that have little or no validity in this respect. These "ages" are commonly cited and used to track hotspots, calculate plate velocities etc.

Given the nature of material (mafic) dated, the argon dating methods are the best tool. It has been shown that many ages related to hotspot volcanism in the Indian and Atlantic Oceans, are invalid as accurate estimates of time of the crystallization (Baksi, 1999, Jour. Geol., 2005, in press, GSA Spec. vol.).

Herein, I critically evaluate ages for hotspot tracks in the Pacific Ocean. I concentrate on $^{40}Ar/^{39}Ar$ incremental heating ages and show that many plateau/isochron ages:

(A) Fail to meet requisite statistical tests for validity as meaningful ages

(B) Numerous steps contain large amounts of atmospheric argon, derived from altered sites.

The aim is to eliminate incorrect ages that have "cluttered up" the literature. A longer term goal will be to arrive at a list of robust ages for examining hotspot volcanism in the Pacific Ocean.

General ground rules followed can also be checked at:

www.mantleplumes.org/ArAr.html

(1) First, I look to reports that utilized the requisite statistical tests in the proper manner.

These include data on the Hawaiian-Emperor Chain (Dalrymple and Garcia, 1980; Dalrymple et al., 1980; DSDP 55). Some steps contain quite high amounts of atmospheric argon, suggestive of alteration. This would tend to lead to ages that are too young. As an example, the age of the bend in the Chain appears to be in the 47-50 Ma range (Sharp and Clague, 1999, 2002, AGU abstracts), older than the earlier suggested ~43 Ma.

(2) <u>Musicians Smnts</u> - Pringle, 1993, AGUMonograph.

This report contains numerous ages that meet the requisite statistical tests and appear to be valid approximations to the crystallization age. In their Table 3, goodness of fit parameters (F) for three isochrons yield probability values (p) that are too low (< 0.05).

(a) Khatchachurian Smnt – KK804 1-10 – p ~ 0.004.

(b) Mahler Smnt – KK804 7-17 (50-150μ) – $p < 10^{-6}$

(c) Haydn Smnt – Plag total fusions, p ~ 0.001.

Some samples contain large amounts of atmospheric argon. These are altered and any resulting plateau/ isochron ages are liable to be too low.

(3) The next group of papers reported ages that must be rejected on

(a) statistical grounds or

(b) as $(^{40}Ar/^{36}Ar)_{initial}$ - from the isochron plot – is < atmospheric value (295.5).

This includes the results of:

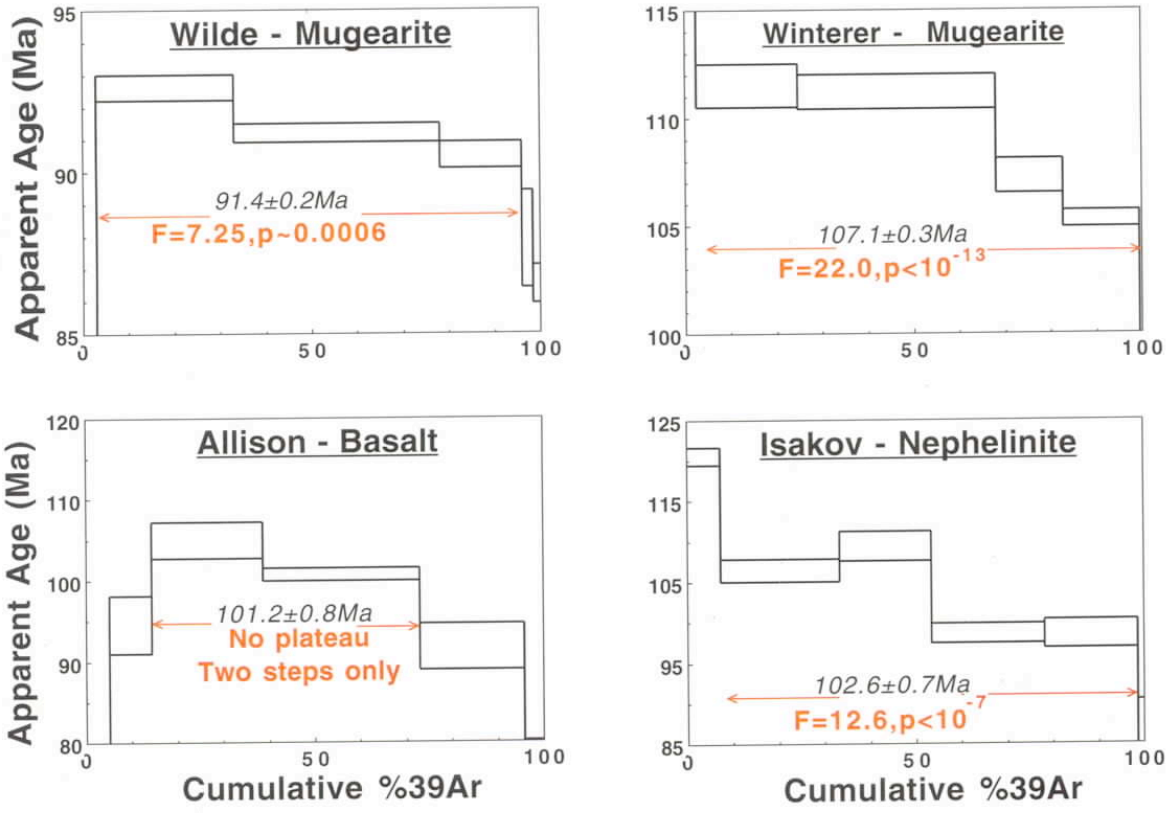
(a) Winterer et al. (1993), AGU Monograph

(b) Ozima et al. (1977), Geophys. Jour. RAS

(c) Saito and Ozima (1977), EPSL

Specific cases are illustrated using age spectra.

Plateau sections/ages as reported in Winterer et al. (1993) shown for four samples.



All four "ages" show $p < 0.05$; these and most of the others for Cretaceous guyots in the Northwest Pacific, are rejected.

Ozima et al. (1977)

Problems:

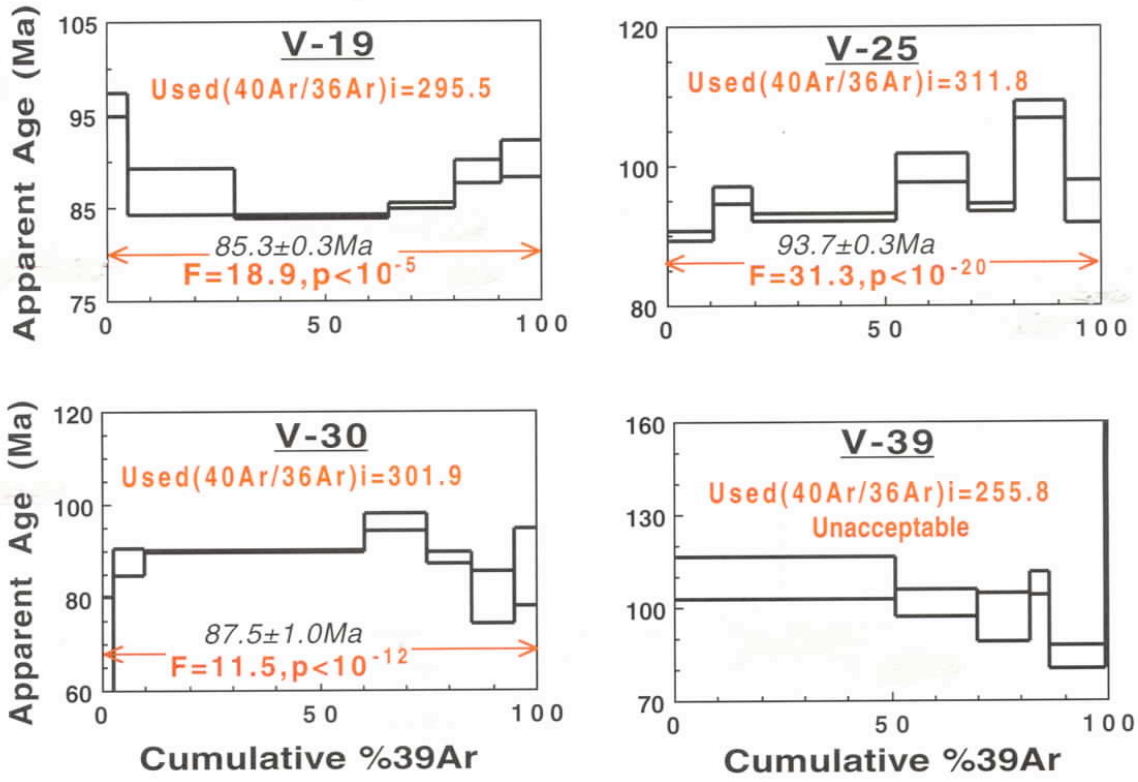
Step ages and errors are incorrectly reported in many cases, as based on isotopic data in their Table 2.

The goodness of fit values (F) were reported as the square root of the proper values. This raises the F values (e.g from 3 to 9), and leads to very small probability values.

Similar problems exist for the ages in Saito and Ozima (1977)

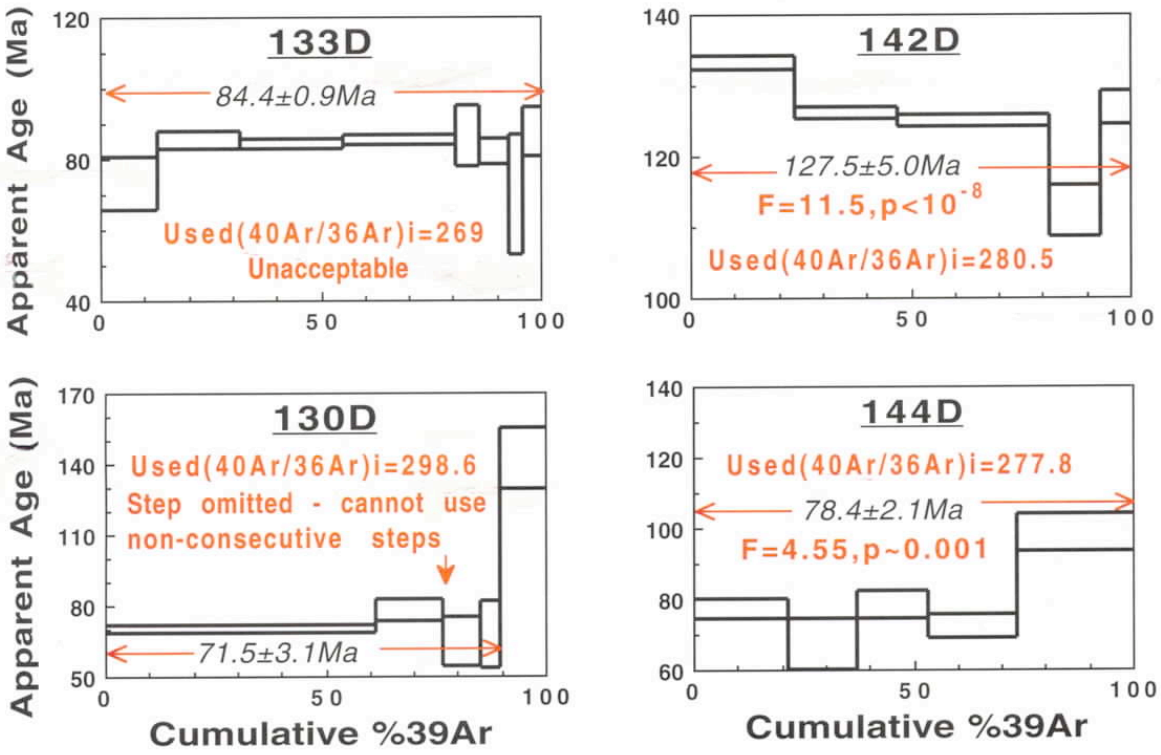
and in many instances, $(^{40}Ar/^{36}Ar)_{initial}$ is < the atmospheric value.

Four samples analyzed by Ozima et al. (1977). Step ages recalculated from isotopic data. "Plateau sections" as defined by the authors.



Ages rejected as proper estimates of crystallization values. This paper yielded no valid ages for guyots in the Western Pacific.

Four samples analyzed by Saito and Ozima (1977). Step ages recalculated from isotopic data. Plateau sections as defined by SO77.



All these ages are rejected, for reasons noted in red. This paper yielded no valid ages for submarine rocks in the Western Pacific area.

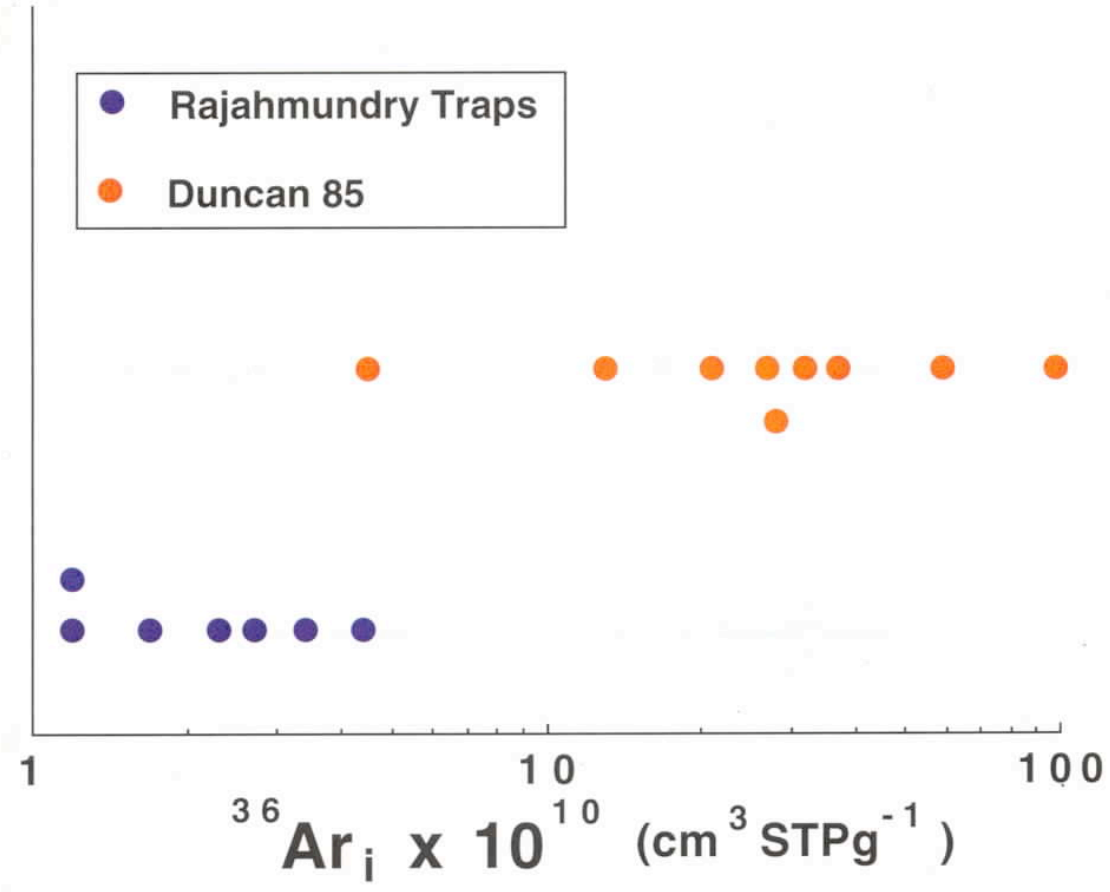
(4) K-Ar dates on whole-rock basaltic material are suspect as ACCURATE ages for crystallization. Almost all samples show alteration, leading to partial loss of $^{40}Ar^*$ and lowered "ages".

Alteration is best gauged by looking to the amount of ^{36}Ar seen in the analyses – a measure of the "atmospheric contamination". For fresh <u>subaerial</u> basalts, this value should be

$$\sim 2\text{-}5 \times 10^{-10} cm^3 STP g^{-1}$$

For <u>submarine</u> rocks, the ^{36}Ar content is generally much higher.

Almost all analyses in Duncan (1985) – New Hebrides-Samoa Lineament - show ~3-20 times higher amounts of ^{36}Ar – rocks are quite altered.



The K-Ar dates used by Gripp and Gordon (2002), in the main, suffer from the same drawback.

(5) Reports that quote ages where the (raw) analytical data are unavailable – e.g. Sager et al. (1993), Lincoln et al. (1993) - AGU Monograph 77, pose numerous potential problems.

Until the raw data are critically evaluated, and "passed" these "ages" should NOT be used as accurate estimates of crystallization ages.

A methodical search through hotspot age data is under way, with emphasis on Pacific Ocean tracks.

Initially, (numerous) invalid ages will be discarded. When a "core" of good data is arrived at, the hypothesis of linear progression of ages on hotspot tracks will be reexamined.

In the interim, CAUTION in use of such data is advised. As shown elsewhere (Baksi, 1999, 2005) few if any hotspot track ages are confirmed in the Atlantic and Indian Oceans.

I conclude with a request to editors of journals:

If a manuscript contains $^{40}Ar/^{39}Ar$ age data, AT LEAST one of the reviewers must be a person fully conversant with the methods of evaluating such data critically.

My apologies that I am unable to address questions/criticisms, in person.

These should be sent to abaksi@geol.lsu.edu.