WHERE DOES BRACHINA COME FROM ?

G. Crozaz[1] and P. Pellas[2]
[1]Dept. Earth and Planet. Sciences and McDonnell Center for Space Sci., Washington Univ. St.Louis MO 63130, [2]L.A.n°286 du CNRS, 61 rue Buffon, 75005 Paris, France.

Brachina has been classified as a chassignite according to chemical and petrological observations (1,2). If so, its crystallization age could be ∿1.23 Gy by analogy with ^{39}Ar-^{40}Ar and Rb-Sr chronologies of Chassigny (3,4). On the other hand, clear cut differences in oxygen isotopic signatures (5) discard any possible genetic relationship between the two "chassignites", in spite of an ingenious and ad hoc mixture model recently proposed to overcome the difficulty and to reconcile it with a possible origin on Mars for Brachina (6). The data presented below point to a very early formation of Brachina at ∿4.5 Gy ago, when ^{244}Pu ($T_{1/2}$ = 82 My) was still alive.

EXPERIMENTAL. About 10 mg of Brachina (4489D, A.M.N.H.) were sampled at a distance of 5-8 mm from the fusion crust. After crushing, various mineral phases were handpicked, mounted in epoxy, polished and etched. A 2nd fraction, all olivines, has been etched directly in the EDTA solution (7) and observed with the optical microscope in order to detect crystal surfaces which were irradiated by adjacent U-rich minerals. These irradiated surfaces were then studied with the scanning electron microscope. All the data already obtained (SEM values, unless specified) are displayed in the track density histograms of Fig. 1.

HEAVY COSMIC RAY COMPONENT. In olivines, cosmic ray track densities cluster between 1.4 and 4.5 × $10^6/cm^2$. These values have to be multiplied by a factor of 2,4 in order to get the equivalent c.r. track densities in the diopsides and apatites (8) which, therefore, are contained in the interval 3.5-11 x $10^6/cm^2$.

FISSION TRACK COMPONENT. After subtraction of the cosmic ray track contribution, large track "excesses" are present both in diopsides and apatites with the following values : 3-8 and 12-45 x $10^6/cm^2$, respectively. That a fission track component is present in Brachina is further evidenced by the presence of olivine crystals with surface zones overirradiated with respect to the c.r. track densities in the interior of the same crystals. These "excess" tracks were registered from adjacent diopside and/or apatite grains once in close contact with the olivine crystals (Fig.1, top). Indeed, it is possible to verify the very similar fission track density distribution of these olivine contacts (corrected for both their c.r. track density backgrounds and their 2 Π irradiation geometry condition) with the "excess" track density intervals as defined above for diopsides and apatites. Three olivine contacts at the largest fission track density values (100-160 x $10^6/cm^2$) do not show any relative counterpart in the apatite track density distribution; that suggests the possible presence of a few crystals of merrillite (usually much more enriched in ^{244}Pu than apatite) which, however, have not yet been detected.

Fission tracks in diopside and apatite are mostly due to the spontaneous fission of ^{238}U and possibly ^{244}Pu, plus a small (negligible for a stone) component of induced fission of U and Th during the exposure age. The proper U contents of diopsides and apatites is being measured. Here, we shall assume average U contents of 50 ppb and 2 ppm for diopsides and apatites, respectively. These values agree with those obtained by various groups in the case of meteorites. Furthermore, the upper limit of the U content of Brachina (< 50 ppb) (9) eliminates the possibility that all the fission tracks in diopsides and apatites are due to the spontaneous fission of ^{238}U. Such estimated U contents would produce no more than 0.15 and 6 x 10^6 tracks/cm^2 over a 4.6 Gy period. Thus, we are left with large fission track densities attributable to ^{244}Pu : 2.8-7.8 and 6-39 x $10^6/cm^2$ for diopsides and apatites, corresponding to average Pu contents of ∿0.8 and ∿3.5 ppb, respectively. The strong point is that when Brachina material cooled down to track retention in both mineral phases, ^{244}Pu was still

alive. The Pu content in Brachina apatites, as estimated from the fission track density, seems apparently higher than in chondritic apatites, and corresponds to that measured at the time of fission xenon retention for Estacado and Guarena apatites (∿3.5 ppb) (10). Moreover, Brachina cooled rather fast as it is demonstrated by the similarity of the fission track density distributions between apatites and their olivine contacts. Thus, a "chassignite" was formed at a very early stage, close to 4.5 Gy, with a flat REE pattern (9), an oxygen isotopic fingerprint in the eucrite-pallasite fields (5,11), and within a small body most probably asteroidal in origin. In short, there is no need for invoking a large parent planet like Mars to produce it.

REFERENCES. 1) Johnson J.E. et al. (1977) Rec. South Austr. Mus. 17, 309. 2) Nehru E.C. et al. (1979) Meteoritics 14, 493. 3) Bogard D.D. and Nyquist L. (1979) Meteoritics 14, 356. 4) Nakamura N. et al. (1982) Abstr. 5th Int. Conf. Geochron. Cosmochron. Isot. Geol., Nikko, Japan, p. 263. 5) Clayton R.N. and Mayeda T.K. (1982) in Lunar and Planetary Science XIII, p. 117. 6) Ryder G. (1982) Nature 299, 805. 7)Krishnaswami S. et al. (1971) Science 174, 287. 8) Pellas et al. (1973) Meteoritics 8, 418. 9) Dreibus G. et al. (1982) in Lunar and Planetary Science XIII, p. 186. 10) Pellas P. et al. (1979) in Lunar and Planetary Science X, 969. 11) Clayton R.N. and Mayeda T.K. (1978) Earth Planet. Sci. Lett. 40, 168.

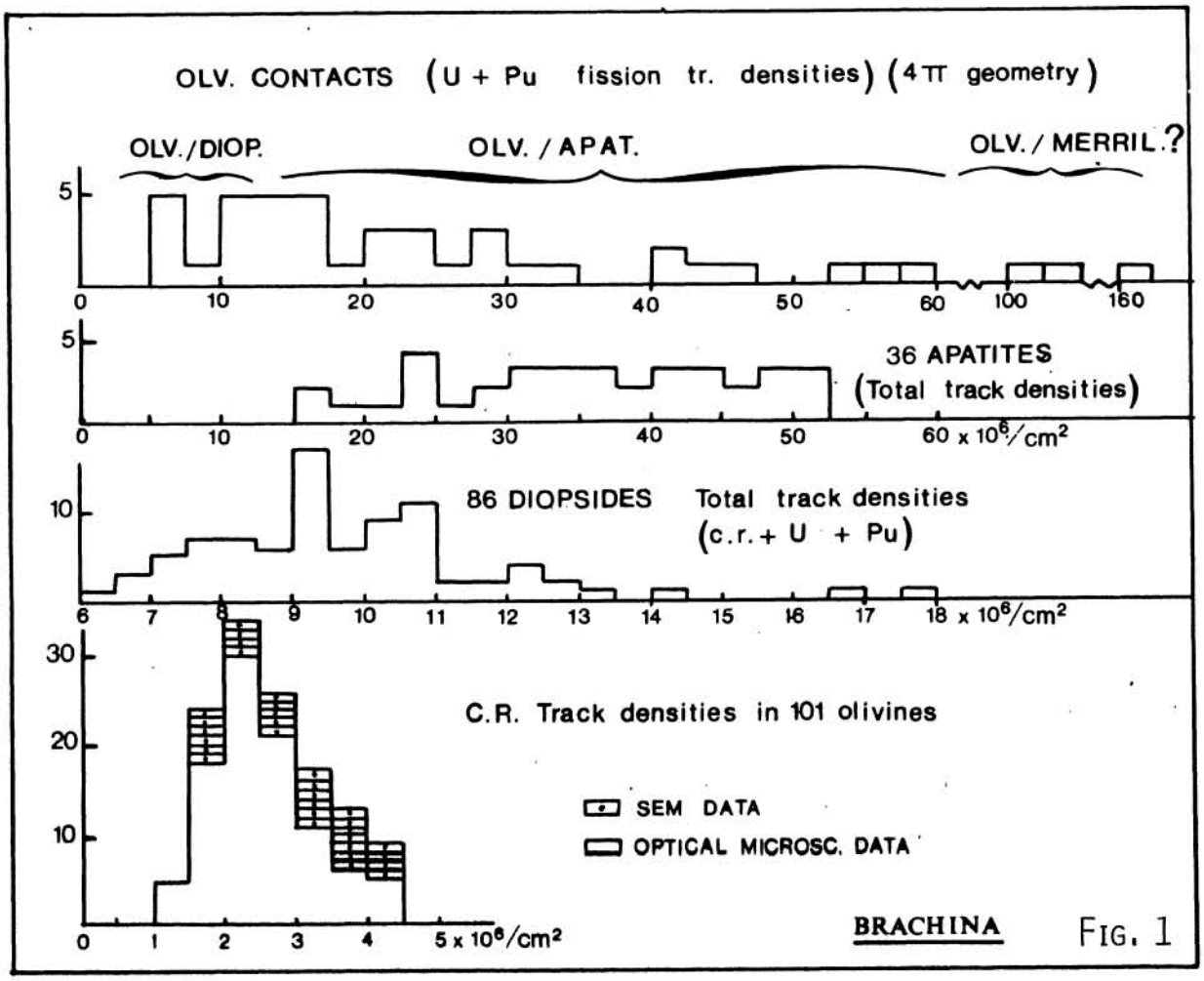

FIG. 1