OSMIUM ISOTOPES IN IVORY COAST TEKTITES: CONFIRMATION OF A METEORITIC COMPONENT AND RHENIUM DEPLETION.

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We used the sensitive negative thermal ionization mass spectrometry method for the measurement of concentrations and isotopic ratios of osmium and rhenium in four Ivory Coast tektites. These tektites have crustal major and trace element compositon, as well as large negative ε_{Nd} (-20) and positive ε_{Sr} (+260 to +300) which are characteristic for old continental crust. We have found Os concentrations ranging from 0.09 to 0.30 ppb, clearly much higher than average crustal values, $^{187}Os/^{186}Os$ ratios of about 1.2-1.7, and low $^{187}Re/^{186}Os$ ratios. These results show unambiguously the existence of a meteoritic component (on the order of 0.06%) in the Ivory Coast tektites. Low Re abundances are the result of fractionation of Re during the impact.

Tektites are natural glasses occurring on earth in several strewn fields. Geochemical arguments have shown that tektites have been derived by hypervelocity impact melting from terrestrial upper crustal rocks (e.g., [1,2]). For two of the four tektite strewn fields (Ivory Coast, moldavite), a connection to impact craters (Bosumtwi, and Ries, respectively) has been suggested on the basis of chemical, isotopic, and age data. Even though the geochemistry of tektites is in unequivocal favor of an origin by impact melting of terrestrial rocks, the absence of definitive crater identifications as well as the absence of a clear demonstration of the presence of an extraterrestrial contribution to the chemistry of most tektites remains a problem. Tektites consist predominantly of terrestrial material, because the impacting body ("projectile") is vaporized upon impact. Taking into account the complexity of the mixing processes occurring during impact, and the small contribution of the projectile to the total mass of the melt, it is extremely difficult to discover any extraterrestrial contamination of impact glasses and tektites. The only elements that seem to be useful in such an identification are some siderophile elements, especially the platinum-group elements (PGEs). Their abundances and interelement ratios in meteorites are considerably different from terrestrial upper crustal rocks. Studies of PGE abundances in melt rocks and breccias from several impact craters yielded some estimates of the composition of the projectiles (e.g., [3,4]).

These projectile identifications are, however, few and often uncertain. The method has been more successful for melt rocks and impact glasses, but no conclusive results were obtained for any tektite group. Only few tektites have been analyzed for their PGE contents, mainly due to analytical problems at the very low abundance levels present in tektites. Only one H-Mg australite (out of 6 analyzed) showed a distinct PGE enrichment over the typical abundances in upper crustal rocks [5]. Analyses of two Ivory Coast tektites yielded Ir abundances of 0.24 and 0.33 ppb [4,6]. The low abundances precluded the measurement of all PGEs in the Ivory Coast tektites, but Palme et al. [6] suspected that an iron projectile might have been responsible for the Bosumtwi crater. However, no unambiguous identification of an extraterrestrial component has been confirmed for any tektite group, and no definite meteorite group could be allocated to any of the reported PGE enrichments. Part of the problem seems to be the possibility of irregular fractionation between the PGEs and other siderophile elements during impact [7,8].

We suggest that the study of Os isotopes is able to provide unambiguous proof for the presence of an extraterrestrial component in impact glasses and tektites because the ratio of $^{187}Os/^{186}Os$ in meteorites is distinctly different from the ratio in old continental crustal rocks that make up the target material for tektites. It is also unlikely that there is a significant fractionation of Os isotopes during impact. Only one earlier study [9] tried to determine Os isotopes in impact melts; it succeeded only partly because the analytical methods were not yet sensitive enough.

We used the highly sensitive negative thermal ionization technique for the determination of Os isotopes and the abundances of Os and Re (e.g., [10]) in four Ivory Cost tektites. Improved laboratory procedures yielded total procedural blanks of 2 pg for Os and 12 pg for Re for the acid digestion-distillation-anion exchange procedures used to dissolve the sample and purify Re and Os. We found Os concentrations of about 0.09-0.30 ppb, which are clearly elevated over normal crustal values (Fig. 1). Re, on the other hand, having concentrations of only 0.004-0.020 ppb, is strongly depleted relative to both continental crust (Fig. 1) and meteorites. The $^{187}Os/^{186}Os$ ratios are shown in Fig. 2. The ratios are low for all four tektite samples, and are inconsistent with crustal values. Also plotted in Fig. 2 are carbonaceous chondrites and iron meteorites, which define the meteoritic (4.56 Ga) isochron [11,12]. The tektites plot to the left of the meteorite isochron, while crustal contamination would have caused an elevated $^{187}Re/^{186}Os$

ratio. Laboratory procedures can be excluded as a source for the low Re contents (see [13] for details). In contrast, the low Re values indicate loss of Re during the impact, in agreement with earlier suggestions [5].

Our model is shown in Fig. 3. The impact occurred about 1.1 Ma ago, into old crustal target rocks having ε_{Nd} of -20 and mantle extraction Sm-Nd model ages of about 1.9 Ga [14]. Crustal rocks of that age should define a mixing line with meteoritic material (Fig. 3). The $^{187}Re/^{186}Os$ ratio for typical crustal rocks can vary between about 300-600; we use a conservative estimate of about 300. If the Os in the tektites would be of crustal origin, it would plot far to the right and above the borders of Fig. 3. The low $^{187}Os/^{186}Os$ ratios in the tektites are therefore unambiguous proof that almost all the Os is meteoritic. During impact, crustal rocks are mixed with the meteoritic component (represented by the intercept of the mixing line with the meteorite isochron), and through concurrent Re loss they move to the left of the meteorite line. The $^{187}Os/^{186}Os$ ratios in the Ivory Coast tektites are compatible with an iron projectile, although that distinction is not unambiguous.

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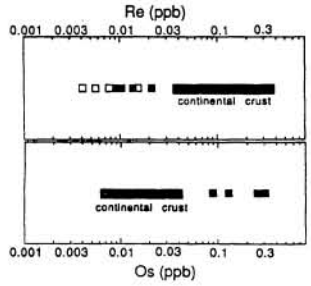

↑Fig. 1: Range of Os and Re concentrations in Ivory Coast tektites compared to crustal values (from [15]). Solid symbols are maximum possible Re values assuming no blank correction for Re. Open symbols are corrected for average laboratory blank.

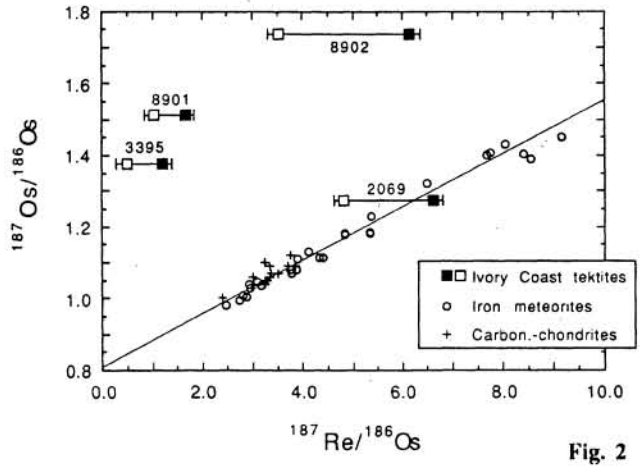

Fig. 2

→Fig. 2: $^{187}Re/^{186}Os$ vs. $^{187}Os/^{186}Os$ for 4 Ivory Coast tektite samples, compared to carbonaceous chondrites [11] and iron meteorites [12]. The error bars are defined by uncertainties in the level of the Re blank. The error bars for Os are smaller than the symbols. Symbols see Fig. 1.

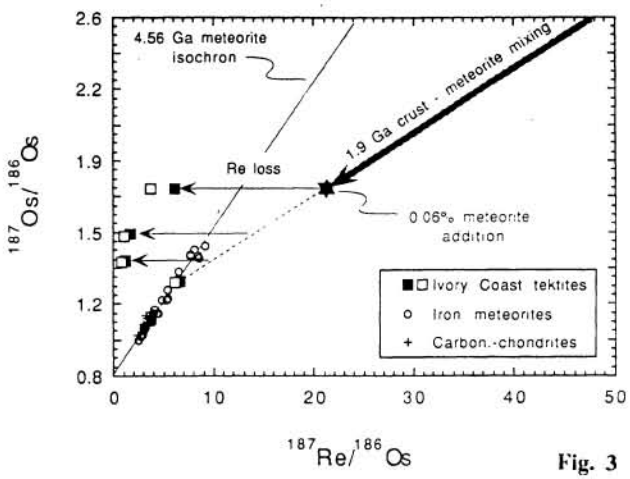

Fig. 3

→Fig. 3: Mixing model between 1.9 Ga old crustal rocks (having $^{187}Re/^{186}Os$ ratios of about 300) with a meteoritic component, and subsequent loss of Re.