U-SERIES DISEQUILIBRIUM IN LATERITIC PROFILES ON A U-MINERALIZED AREA (LAGOA REAL, BRAZIL) : A PRELIMINARY STUDY

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SUMMARY

The activity ratios ($^{234}U/^{238}U$) and ($^{230}Th/^{234}U$) have been investigated in two lateritic profiles from the Lagoa Real area (Brazil) to identify recent radionuclide redistribution. Saprolite which developed on a mineralized albitite containing up to 690 ppm uranium and topsoil have lost uranium since 350 ky while the percentage of ^{238}U leaching is constant for several samples. ($^{234}U/^{238}U$) ratios above 1 are interpreted as ^{234}U retention in the resistate minerals during leaching . In the saprolite and the topsoil developed on the gneiss, the ($^{230}Th/^{234}U$) ratios are always less than unity indicating recent uranium enrichment.

INTRODUCTION

Prospecting uranium deposits in lateritic areas is very difficult because uranium and some of its daughters are mobile during soil formation and it is rather difficult to understand the significance of a radiometric anomaly. The behavior of U and Th isotopes in lateritic profiles developed in mineralized areas has been documented in only a few cases (e.g. Lowson et al, 1986; Short et al, 1988). In this study, disequilibrium between ^{238}U, ^{234}U and ^{230}Th has been investigated in two profiles located on a plateau in the Lagoa Real area where several uranium deposits are already known (Maruejol, 1987). Under closed geochemical conditions, the U and Th isotopes of the ^{238}U series, ^{238}U ($t_{1/2}$= 4.49 10^9 y), ^{234}U($t_{1/2}$= 2.48 10^5 y) and ^{230}Th ($t_{1/2}$= 7.52 10^4 y), attain secular equilibrium within about 1.2 My. Open geochemical conditions lead to significant U/Th fractionation and isotopic disequilibrium between ^{238}U, ^{234}U and ^{230}Th which could be used to recognize the processes involved in the formation and evolution of the lateritic soils.

MATERIALS AND ANALYTICAL METHODS

The studied samples were collected from two lateritic profiles from the Lagoa Real area in the southwestern part of the Bahia state in Brazil. One profile is a uranium-enriched laterite which was derived from an albitite and surrounding gneiss. The other profile was derived from a gneiss and shows no uranium mineralization. The two studied profiles, 7 and 5 m in depth respectively, show two main superimposed zones which are, from the bottom to the top (Muller et al., 1991; figure 1 and 2): (1) a sandy, porous and friable saprolite which preserves the preexisting rock structure and texture and where the main weathering products are large (50 µm) booklets of kaolinite derived from the weathering of feldspars and micas and associated with tiny crystals of iron oxides and oxyhydroxides (hematite and gœthite); (2) a topsoil zone, in which the rock structure is no longer observed and which consists of red-yellowish, soft and clayed materials, where small (<1 µm) platelets of kaolinite are intimately associated which iron oxides and oxyhydroxides. Through these two profiles the total iron oxides (expressed in wt. % Fe_2O_3) remains in the range 5-9 wt. %.

The activities of ^{238}U, ^{234}U and ^{230}Th were determined by alpha spectrometry using a $^{232}U/^{228}Th$ tracer. The results are reported with a confidence level of ± one standard deviation (1 σ) based on counting statistics. Induced fission tracks using an external Kapton detector and irradiated in the Orphée reactor (Saclay) were used to determine the distribution of uranium in the samples. U and Th were determined by ICP at the CRPG (Nancy, France).

RESULTS AND DISCUSSION

U and Th whole rock data, the U/Th ratio, the isotopic ratios ($^{234}U/^{238}U$) and ($^{230}Th/^{234}U$) and the sample locations in the lateritic profile on the mineralized albitite and on the gneiss are illustrated in Figures 1 and 2, respectively.

PROFILE ON THE ALBITITE

The latertic profile on the albitite (Figure 1) reaches coherent weathered albitite at 7 meters depth. Uranium and thorium contents from this profile are variable: 65 to 690 ppm for U and 19 to 42 ppm for Th. The saprolite is richer in U and Th than the topsoil zone. The U/Th ratio decreases significantly from the bottom to the top of the saprolite and slighly from the bottom to the top of the topsoil. The present limit between the saprolite and the topsoil probably corresponds to the ancient limit between a mineralized albitite and a more gneissic part above. The presence of quartz crystals in the topsoil confirms this interpretation.

Whereas most of the ($^{234}U/^{238}U$) are equal to unity, four samples (1-23 in the saprolite and 27-35 in the topsoil) have ($^{234}U/^{238}U$) significantly greater than 1 (Figure 1). In general, during weathering, ^{234}U is more easily leached than ^{238}U and the solid phase is depleted in ^{234}U. However, Shirvington (1983) notes that during experimental leaching of weathered ores, ^{238}U was preferentially leached in relation to ^{234}U. This could be explained by ^{234}U implantation in the resistate material (Lowson, Short, Davey and Gray, 1986). A recent input of U could also be involved, although this seems unlikely because the ($^{230}Th/^{234}U$) ratio is much above 1.

The ($^{230}Th/^{234}U$) and ($^{230}Th/^{238}U$) ratios are significantly above 1 for all the samples except one (26) which is located at the bottom of the topsoil zone. Considering the negligible chemical leaching of ^{230}Th (Short , Lowson and Ellis, 1988), ($^{230}Th/^{234}U$) and ($^{230}Th/^{238}U$) ratios above 1 imply U leaching since 350 ky except a small accumulation at the bottom of the topsoil zone. In a ($^{238}U/^{232}Th$) vs ($^{230}Th/^{232}Th$) diagram (Figure 3), it appears that the amount of ^{238}U leaching is rather constant for five samples (8-1-23-27 and 35).

PROFILE ON THE GNEISS

The lateritic profile on the gneiss (Figure 2), which reaches coherent weathered gneiss at 5 meters depth, exhibits a narrow range of U (4.7 to 7.7 ppm) and Th (27 to 61 ppm) contents. The U/Th ratio ranges from 0.12 to 0.2. These values are much lower than those in the mineralized albitite.

The (^{234}U/^{238}U) ratios are about 1 in the topsoil zone whereas the sample analyzed from the saprolite has a (^{234}U/^{238}U) ratio of 0.9 (Figure 2). All the samples have a (^{230}Th/^{234}U) ratio less than unity, which indicates that ^{234}U has accumulated during the last 350 ky. In a (^{238}U/^{232}Th) vs (^{230}Th/^{232}Th) diagram (Figure 4) it appears on the contrary to the profile on albitite, that the whole profile on gneiss is ^{238}U enriched.

The percentage loss or gain of uranium could be calculated from the saprolite to the topsoil (Figure 5) with Th being considered as immobile element during the laterization process (cf Braun and Pagel, this volume). A mass balance calculation indicates that the topsoil zone is not U-enriched or depleted with respect to the saprolite.

Fission track studies of these two profiles have shown that secondary uranium content correlate to iron oxides.

CONCLUSONS

(1) Significant disequilibrium in the U series isotopes measured in lateritic profiles on a mineralized albitite and surrounding gneisses indicates that radionuclide mobilization, especially uranium, has occurred within the past 350 ky.

(2) In the profile on albitite , it is shown that the present saprolite-topsoil limit corresponds roughly to the transition between an albitite and a gneiss. The percentage of U loss is rather constant among the samples.

(3) In the weathered mineralized samples, the (^{234}U/^{238}U) ratios above 1 could be explained by the retention of implanted ^{234}U in the resistate.

(4) In the profile on gneiss, a recent uranium enrichment is noted both in the saprolite and the topsoil zone and if Th is considered as an immobile element, no uranium variation is evidenced between these two zones.

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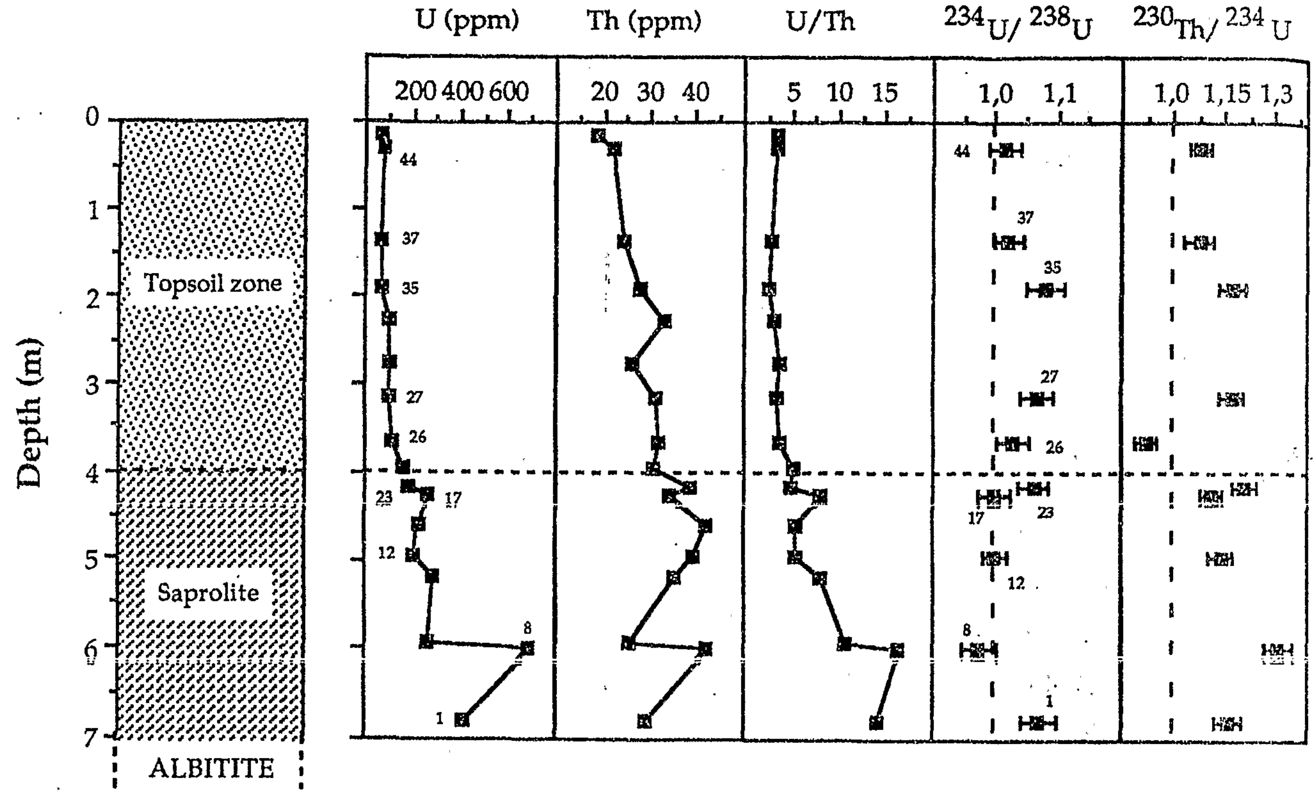

Figure 1: Variation of U and Th concentrations, U/Th ratio and isotopic ratios ($^{234}U/^{238}U$) and ($^{230}Th/^{234}U$) with depth in the profile on the mineralized albitite from the Lagoa Real area (sw Bahia, Brazil). All errors are 1 σ. 23, 44: sample numbers.

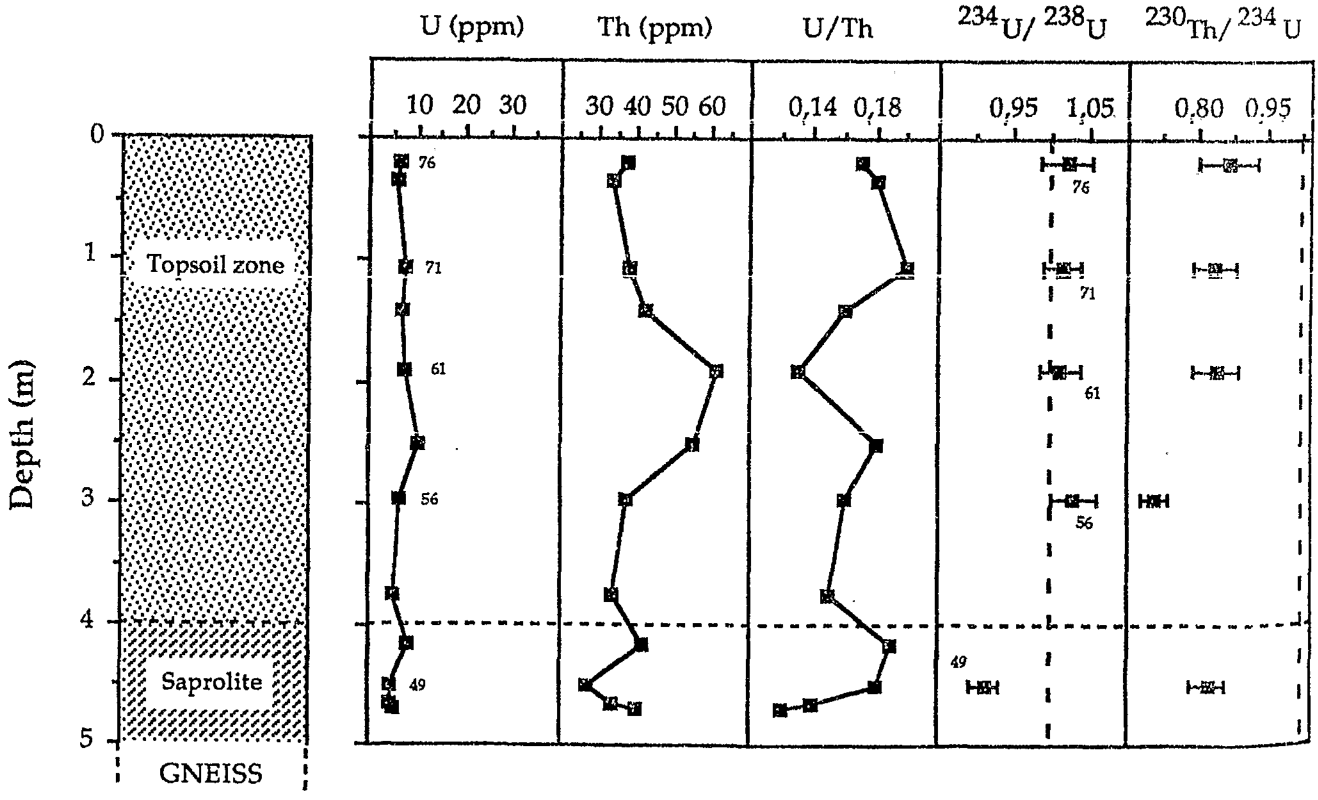

Figure 2: Variation of U and Th concentrations, U/Th ratio and isotopic ratios ($^{234}U/^{238}U$) and ($^{230}Th/^{234}U$) with depth in the profile on gneiss from the Lagoa Real area (sw Bahia, Brazil). All errors are 1 σ. 76, 49: sample numbers.

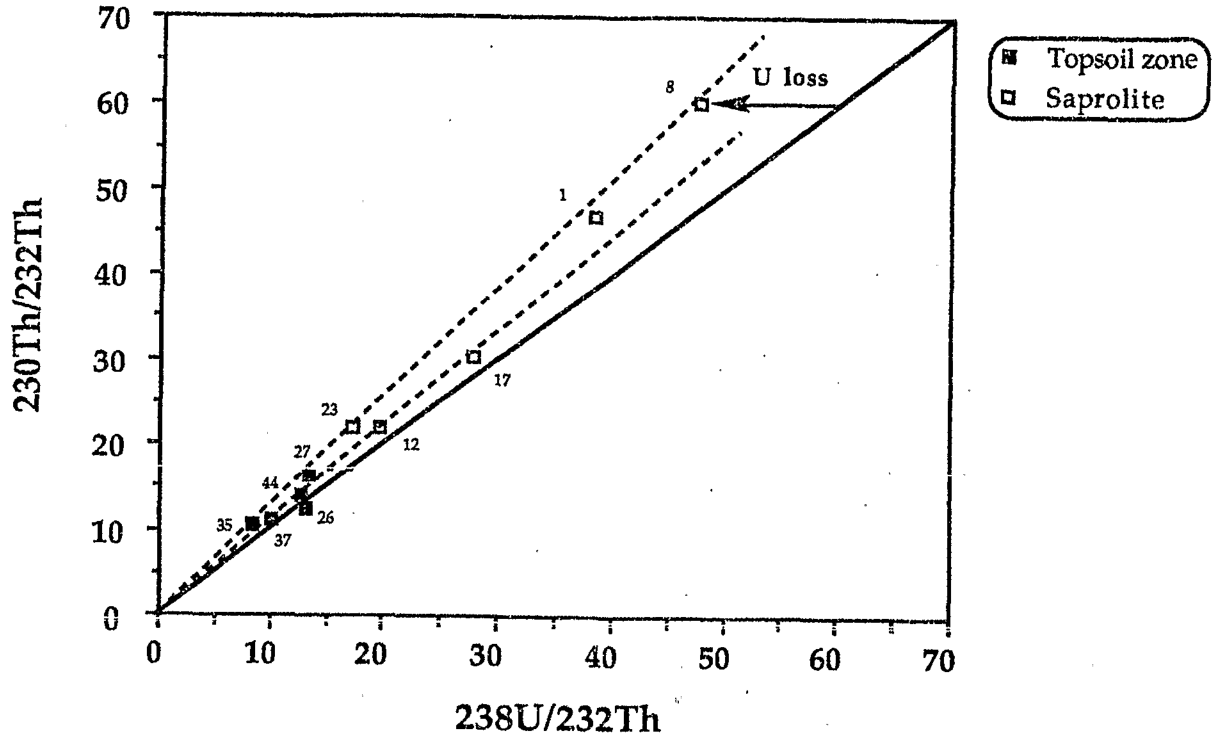

Figure 3: Plots of activity ratios of (^{230}Th/^{232}Th) vs (^{238}U/^{232}Th) for samples from profile on albitite. The broken lines indicate a constant ^{238}U leaching.

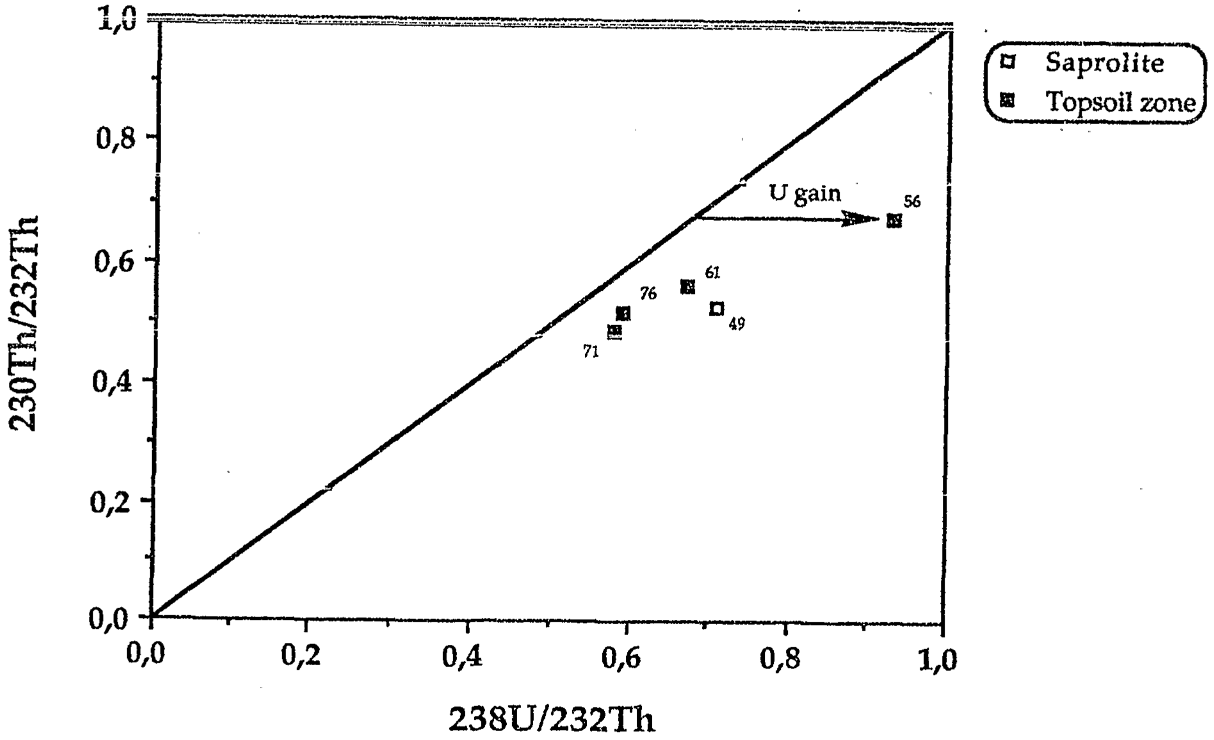

Figure 4: Plots of activity ratios of (^{230}Th/^{232}Th) vs (^{238}U/^{232}Th) for samples from profile on gneiss. ^{238}U was enriched in the upper topsoil and in the saprolite.

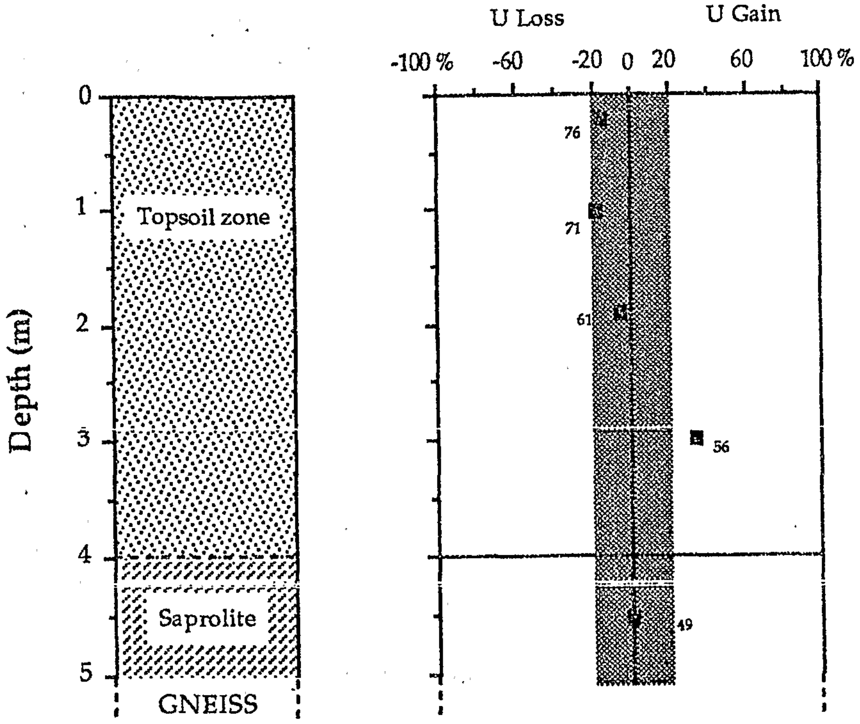

Figure 5: Mass balance calculation, with Th as an immobile element, from the topsoil zone of profile on gneiss.

▨ interval of analytical error (± 20%) in which an element can be considered immobile (Cramer and Nesbitt,1983).

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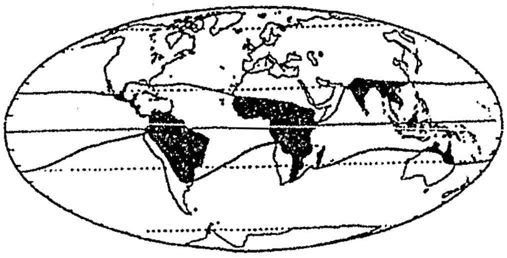

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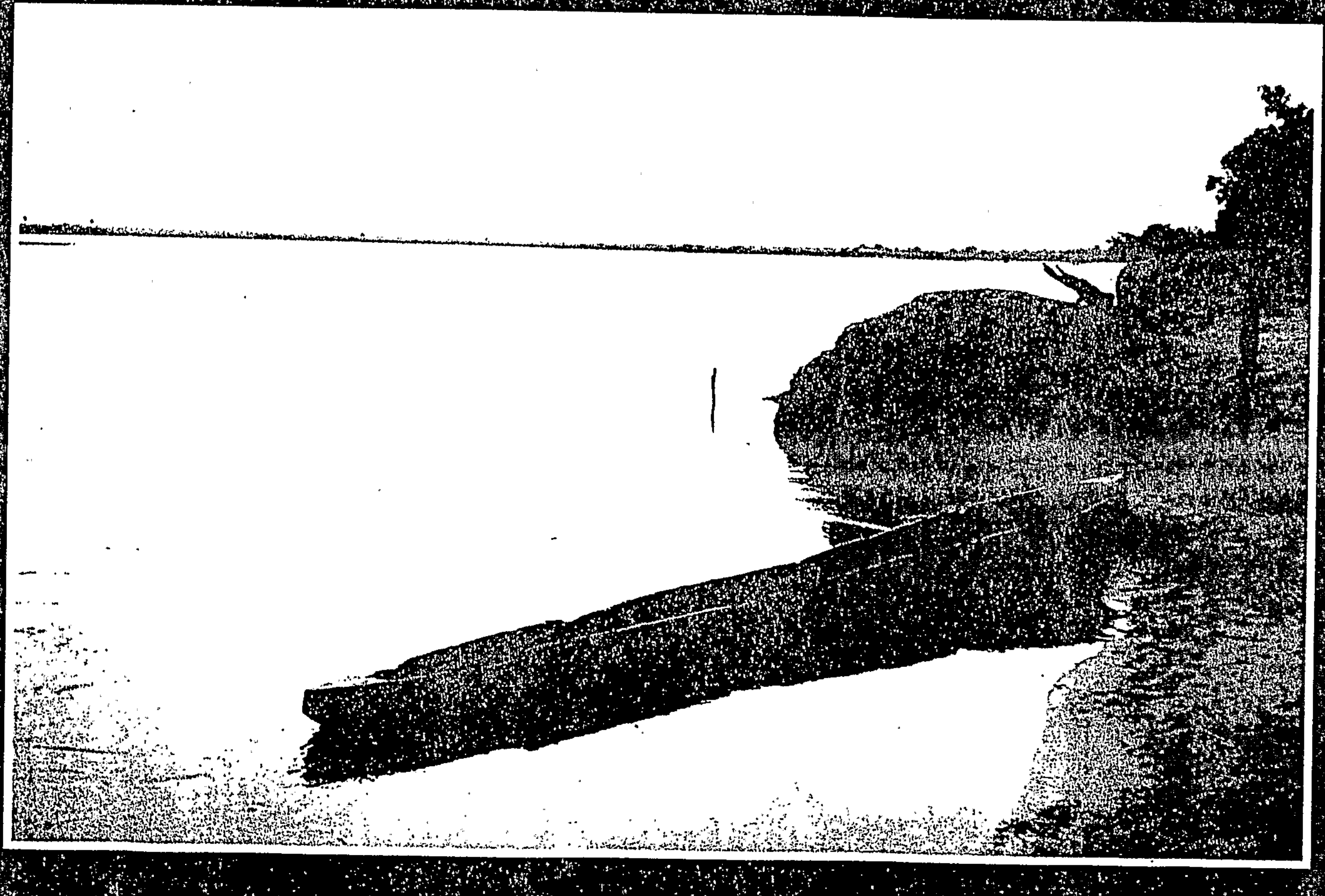

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