URANIUM-LEAD AGES OF ZIRCON MEGACRYSTS AND ZIRCON INCLUDED IN CORUNDUM FROM PEIXE ALKALINE COMPLEX (BRAZIL)

Kitajima, L.F.W.[1], Ruiz, J.[2], Gehrels, G.[3], Gaspar, J. C.[4]

[1]Instituto de Geociencias, Universidade de Brasilia, Campus Universitario Darcy Ribeiro, CEP 70910-900 Brasilia, DF, Brazil. e-mail: luizfwk@unb.br
[2]Department of Geosciences, University of Arizona, Gould Simpson Building, 1040 E. Fourth St., Tucson, AZ 85721-0077, U.S.A. e-mail: jruiz@geo.arizona.edu
[3]Department of Geosciences, University of Arizona, Tucson, AZ, U.S.A. e-mail: ggehrels@geo.arizona.edu
[4]Instituto de Geociencias, Universidade de Brasilia, Brasilia, DF, Brazil. e-mail: gasp@unb.br

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INTRODUCTION

The Peixe Alkaline Complex, Brazil, contains unusual mineral occurrences. Among them are zircon megacrysts (there are centimetric zircons) that have been subject of economic exploitation since the 1970's. But these crystals have not been studied in detail, in particular with respect to their isotope composition and U-Pb age.

Pegmatites bearing corundum megacrysts also occur inside this complex. These corundum megacrysts also contain millimetric-sized zircon inclusions, which have never been studied before.

The geochronological study of these zircons are important both for the understanding of the complex and the pegmatitic corundum, as well for an improved understanding of the regional geological evolution.

GENERAL GEOLOGY

The Peixe Alkaline Complex is located at the coordinates 12°42'/13°00' S – 48°30'/48°38' W, in the Brazilian state of Tocantins. It was first identified by Barbosa et al. (1969) and later mapped by Martins (1981) and Lemos (1983).

The geotectonic setting of this complex is at the northern half of the Brasilia Fold Belt, a belt of folded metasedimentary and metavolcanic rocks of Mesoproterozoic age (Fuck, 1994). The host rocks are metagreywackes, quartzites and micaschists related to the Serra da Mesa Group. There is a pegmatoid granite to the South that is younger than the complex.

The complex is an elongated plutonic body in intrusive contact with the host rocks (metasedimentary xenoliths were found inside the complex). The size is approximately 30 by 7 km. and its major axis is oriented N-S (Fig.1).

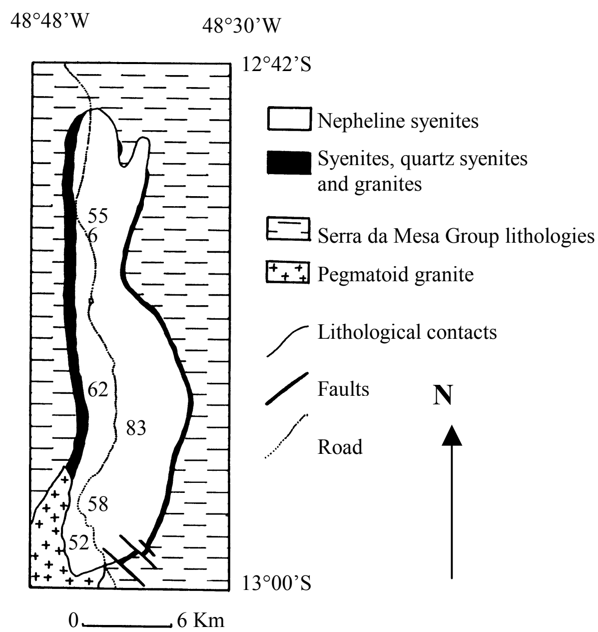

Figure 1. Geological map of the Peixe Alkaline Complex (Tocantins, Brazil), simplified and modified from Lemos (1983). The numbers (6,52,55,58,62 and 83) inside the map are the locations of the analyzed zircon samples.

The main lithology is a miaskitic nepheline syenite, with biotite as the main mafic mineral. Limited facies where the main mafic mineral is magnetite or amphibole were also observed.

More saturated rocks occur as thin strips along the border or inside the SE part of the complex. They are syenites without nepheline, quartz syenites and granites. Some of these syenites contain allanite mineralizations.

Pegmatites of granitic to syenitic composition occur inside and in the vicinity of the complex. Those pegmatites are frequently hosting minerals such as ilmenite, allanite, monazite, corundum and beryl.

These rocks (undersaturated and saturated syenites and granites) are massive to strongly banded or foliated. The general attitude of foliation and banding follows the regional N-S trend. The deformation is related to amphibolite-facies metamorphism during the Brasiliano orogeny (1.0-0.5 Ga). Events of metasomatism probably have affected the complex during this period.

The proposed origin of this complex is during a event of intracontinental rift opening by 1.7-1.5 Ga.. The rift opening is related also with a number of igneous events (A-type granites, mafic-ultramafic complexes) and the deposition of the Serra da Mesa sedimentary units (Nilson et al., 1994; Rossi et al., 1996).

ZIRCON OCCURRENCE AND DESCRIPTION

Zircons are common acessory minerals in all lithologies of the complex, but the zircon megacrysts occur only in the nepheline syenites. It is common to find these megacrysts in the weathered horizon, where they form placer-type deposits. But some in situ occurrences where also observed; in this case the crystals can form up to 5% (modal) of the nepheline syenite. The observed zircon megacryst-bearing nepheline syenite is medium grained and slightly foliated, and the zircons appear to be oriented along to the foliation.

They are millimetric to centimetric in size (there are descriptions of crystals over 50 kg. in weight) and are predominantly bipiramidal or with incipient prismatic faces. They are brown to almost white, with a diamantine luster, and are frequently opaque. There is optical zonation, and recent data indicates slight enrichment in U, Th and REE toward the center.

These megacrysts may present fractures filled with a brownish “rusty” material. Smaller fractures may also occur along the borders.

The other zircon crystal studied comes from corundum megacrysts. These bluish corundun crystals are pegmatitic and can reach the weight of many kilograms. The included zircon is prismatic and reaches up to 3 mm on its c-axis. Its color is brown, it is semitransparent and appears to be optically zoned.

GEOCHRONOLOGY

Five samples of zircon from nepheline syenites (labeled as KP-52, -55, -58, -62 and 83) and two samples from corundum (labeled as KP-6) were analyzed by isotope dilution-thermal ionization mass spectrometry (ID-TI-MS) for U-Pb ages. The numbers on each label indicate their position in the complex (see Fig. 1). Two small, clean fragments were extracted from each zircon, care being taken to avoid possible inclusions or fractures.

Sample preparation and isotope dilution were done as described by Gehrels (2000). The results are presented in Table 1.

TABLE __. U-Pb ISOTOPIC DATA AND AGES

						Isotope ratios		Apparent ages (Ma)		
Grain type	Grain wt. (µg)	Pb_c (pg)	U (ppm)	$^{206}Pb_m/^{204}Pb$	$^{206}Pb_c/^{208}Pb$	$^{206}Pb^*/^{238}U$	$^{207}Pb^*/^{235}U$	$^{206}Pb^*/^{238}U$	$^{207}Pb^*/^{235}U$	$^{207}Pb^*/^{206}Pb^*$
KP6										
1	41	66	1146	3865	18.3	0.088729 ± 0.46	0.71856 ± 0.86	548	550	557 ± 15
1	40	315	12797	9470	29.8	0.091482 ± 1.09	0.74154 ± 1.15	564	564	559 ± 7
KP52										
1	39	9	129	8316	8.3	0.244303 ± 0.39	3.15110 ± 0.49	1409	1445	1499 ± 5
1	35	41	394	4980	5.9	0.251546 ± 0.77	3.25156 ± 0.87	1446	1469	1503 ± 7
KP55										
1	51	8	567	3973	5.3	0.173789 ± 0.67	1.98436 ± 0.84	1033	1110	1265 ± 10
1	38	17	1078	33400	2.7	0.225418 ± 0.75	2.79158 ± 0.78	1310	1353	1422 ± 4
KP58										
1	44	10	167	1096	20.4	0.237286 ± 1.04	3.06598 ± 1.38	1373	1424	1502 ± 16
1	51	11	111	8430	27.7	0.256375 ± 0.60	3.30412 ± 0.67	1471	1482	1498 ± 5
KP62										
1	61	5	476	80270	4.9	0.260044 ± 0.65	3.35930 ± 0.68	1490	1495	1502 ± 4
1	40	39	732	11528	6.5	0.260419 ± 0.73	3.36461 ± 0.78	1492	1496	1502 ± 5
KP83										
1	42	7	248	25990	4.8	0.260495 ± 0.45	3.36429 ± 0.49	1492	1496	1501 ± 4
1	32	9	534	30940	3.3	0.256052 ± 0.57	3.29704 ± 0.61	1470	1470	1496 ± 4

Each analysis is from a small chip off of the rim of a much larger grain.
$^{206}Pb/^{204}Pb$ is measured ratio, uncorrected for blank, spike, or fractionation.
$^{206}Pb/^{208}Pb$ is corrected for blank, spike, and fractionation.
All uncertainties are at the 95% confidence level.
Uncertainties in isotope ratios are in percent. Uncertainties in ages are in millions of years.
Most concentrations have an uncertainty of 25% due to uncertainty in weight of grain. Constants used:
$^{238}U/^{235}U = 137.88$. Decay constant for $^{235}U = 9.8485 \times 10^{-10}$. Decay constant for $^{238}U = 1.55125 \times 10^{-10}$.
Isotope ratios are adjusted as folllows:
(1) Mass dependent corrections factors of: 0.14 ±0.06 %/amu for Pb and 0.04 ±0.04 %/amu for UO_2.
(2) Pb ratios corrected for 0.005 ± 0.003 ng blank with $^{206}Pb/^{204}Pb = 18.6 \pm 0.3$, $^{207}Pb/^{204}Pb = 15.5 \pm 0.3$,and $^{208}Pb/^{204}Pb = 38.0 \pm 0.8$.
(3) U has been adjusted for 0.001 ± 0.001 ng blank.
(4) Initial Pb from Stacey and Kramers (1975), with uncertainties of 1.0 for $^{206}Pb/^{204}Pb$, 0.3 for $^{207}Pb/^{204}Pb$, and 2.0 for $^{208}Pb/^{204}Pb$.
All analyses conducted using conventional isotope dilution and thermal ionization mass spectrometry, as described by Gehrels (2000).

Table 1. Results of the Peixe Alkaline Complex zircons U-Pb analysis

NEPHELINE SYENITE ZIRCONS

These zircons are relatively U-rich (between 110 and 1078 ppm). With one exception, the samples yield concordant to slightly discordant U-Pb ages, with the discordant analysis forming a linear array on a concordia diagram.

The lower intercept of this discordia line was calculated as 577±26 Ma, while the upper intercept – where most of the analyses are clustered – was calculated as 1503±3 Ma (Fig. 2)

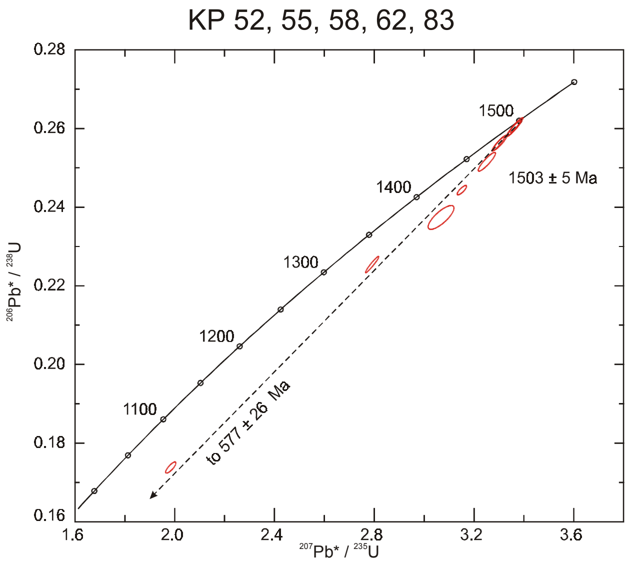

Figure 2. U-Pb concordia plot for the zircons in Peixe Alkaline Complex nepheline syenites.

CORUNDUM ZIRCONS

The corundum-included zircons are richer in U than the nepheline syenite ones. The measured concentrations for two samples were 1146 to 12797 ppm. Those results are concordant with previous electronic microprobe and ICP-Ms analysis done by the authors.

The two samples analyzed yield $^{207}Pb/^{206}Pb$ ages of 557±15 and 559±7 Ma and $^{206}Pb/^{238}U$ ages of 548±3 and 564±6 Ma (Fig. 3). The reason for this lack of overlap is uncertain.

DISCUSSION

Rossi et al. (1996) describes preliminary studies on Peixe Alkaline Complex zircon separates (not megacrysts, but 900 µm crystals), where only two crystal ages of 1470±8 Ma were determined. No further data was released, and this data remained to be confirmed.

The high precision analyses on the nepheline syenite zircon crystals and the value obtained (1503±3 Ma) confirms and refines this preliminary age.

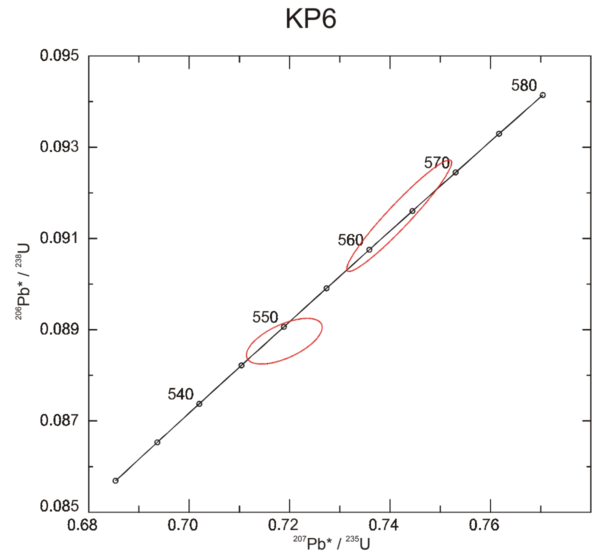

Figure 3. U-Pb concordia plot for the zircons included in corundum pegmatitic megacrysts from Peixe Alkaline Complex.

This age is in accordance with the proposed regional geologic evolution, based on continental rifting at the Mesoproterozoic. A-type granitoids of the northern Brasilia Fold Belt and mafic-ultramafic complexes (Niquelandia and Barro Alto) yield ages between 1.5 and 1.7 Ga (Pimentel et al., 1991; Ferreira et al., 1992; Rossi et al., 1992). Such alkaline-undersaturated rocks are often related to a continental rifting tectonic setting.

The more discordant U-Pb ages and the lower intercept of the discordia line (577 Ma) relates to a metamorphic-metasomatic event that led to the observed Pb loss. This age is, in theory, related to the late stage of the Brasiliano orogeny, which lasted from the late Proterozoic (1.0 Ga) to the Cambrian (570-500 Ma).

The similarity of the ≈560 Ma zircon included in the corundum and the ≈577 Ma lower intercept of the discordia line defined by the nepheline syenite zircons indicate that the 560-570 Ma age may be an event related not only to deformation and metasomatism, but also to igneous activity of a sort not yet well defined. Igneous activity of this age has been recognized as including high-K granites and gabbro-dioritic intrusions in the southern Brasilia Fold Belt at ≈560-588 Ma, as determined by Pimentel et al. (1996). It is possible that the pegmatoid granite that occurs in the Peixe Complex region is related with this activity (this granite in particular has not yet been dated).

The corundum may have crystallized from a new generation of pegmatitic alkaline and undersaturated magma, as suggested by Sutherland et al. (1998), or was a product of reaction between a granitic (saturated) magma and the undersaturated alkaline host rock, as suggested by Guo et al. (1996a,b).

CONCLUSIONS

The zircon megacrysts from Peixe Alkaline Complex nepheline syenites crystallized at 1503±3 Ma, and suffered a metamorphic-metasomatic event that led to Pb loss at about 577 Ma. The 1.5 Ga age is consistent with preliminary age studies (Rossi et al., 1996) and with the proposed regional geotectonic evolution (Nilson et al., 1994).

The zircon included in corundum was crystallized at 560 Ma and did not suffer any noticeable Pb loss. This age is similar to the metamorphic-metasomatic age of the nepheline syenite zircons, what may indicate that, in this period, there were also igneous events. This igneous event was possibly responsible for the genesis of the corundum-bearing pegmatite.

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