The expansion of *Araucaria* forest in the southern Brazilian highlands during the last 4000 years and its implications for the development of the Taquara/Itararé Tradition

José Iriarte and Hermann Behling

An examination of the late Holocene environmental and cultural sequences of the southern Brazilian highlands indicates that the colonisation of this region by the Taquara/Itararé people is associated with the expansion of *Araucaria* forest resulting from the onset of wetter climatic conditions in the region, which started between around 1410 and 900 cal. yr BP. The more intense and permanent human occupation of this region is associated with the advance of *Araucaria* forest, which provided Taquara/Itararé groups with a newly abundant and reliable resource: *Araucaria* seeds. In addition, we review the evidence for landscape transformation associated with the beginning of food-production in the region. Charcoal records show that local populations may have practiced slash-and-burn agriculture at lower elevations since the beginning of the late Holocene around 4320 cal. yr BP, and continued this practice during the second part of the late Holocene.

Keywords: fossil pollen, Holocene, Brazil, climate change, Taquara/Itararé Tradition, Araucaria forest, human-environment interactions

Introduction

The archaeology of the late Holocene of the southern Brazilian highlands (hereafter SBHs) has received a new impetus in the last decade through the developments of several new archaeological projects (e.g., Beber 2005; Chmyz *et al.* 2003; De Masi 2005; Robrahn-González and DeBlasis 1998; Schmitz 2002). In parallel, new paleoecological work carried out in the region (Behling 1995; 1997a; 1997b; 2002; Behling and Pillar 2007; Behling *et al.* 2004; 2005; Bissa *et al.* 2000; Garcia *et al.* 2004; Iriarte 2006a; Ledru *et al.* 1998; Scheel-Ybert 2000; 2001) has substantially expanded and refined our understanding of the mid- and late-Holocene environments. In turn, improved environmental reconstructions

© 2007 Association for Environmental Archaeology Published by Maney DOI 10.1179/174963107x226390 have allowed archaeologists to explore humanenvironmental dynamics in more precise ways (Iriarte et al. 2004; Rodríguez 2005; Scheel-Ybert 2001; Schmitz 2001/2002). This paper reviews the existing archaeological data and correlates it with the paleoenvironmental evidence gathered for the region. The comparison indicates that the climatic fluctuations that took place during the mid and late Holocene had a major impact on the pre-Hispanic groups that inhabited the region. Ten pollen sequences from the Brazilian states of Rio Grande do Sul, Santa Catarina, and Paraná document the beginning of a more humid period starting around 4480-3780 cal. yr BP (4000-3500 ¹⁴C yr BP), which became more intense between about 1410-900 cal. yr BP (1500–1000 ¹⁴C yr BP) depending on the region. The archaeological data indicate that this pronounced late-Holocene environmental change is associated with a more intense occupation of the SBHs as evidenced by the development of the ceramic Taguara/Itararé Tradition. The proliferation of Taquara/Itararé pithouse villages appears to be related to the exploitation of a newly available,

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Figure 1 Southern Brazilian highlands and its major vegetation types showing pollen sites discussed in the text (modified from IBGE 1977). Key: 1. Serra Campos Gerais; 2. Serra da Boa Vista; 3. Morro da Igreja; 4. Serra do Rio Rastro; 5. Aparados da Serra; 6. Cambará do Sul; 7. São Francisco de Paula; 8. Terra de Areia; 9. Lagoa dos Patos; 10. São Francisco de Assis

abundant, and rich resource: *Araucaria* seeds. Furthermore, unprecedented high magnitude charcoal frequencies despite this more humid period appear to mark the onset of human landscape transformation associated with agricultural practices between around 4320 and 2980 cal. yr BP (3950 and 2850 ¹⁴C yr BP).

The southern Brazilian highlands

The SBHs encompasses the southern Brazilian states of Rio Grande do Sul, Santa Catarina, and Paraná as well as part of Misiones Province, Argentina, and Paraguay (Fig. 1). The region is limited to the north by the Paranapanema River and to the south by the Jacuí-Ibicuí rivers. The SBHs decrease in altitude from east to west, from more than 1000 m close to the Atlantic coastal plain to 100 m in the Paraná and Uruguay rivers floodplains. The climate is mesothermic very humid with mean annual temperatures between $15-20^{\circ}$ C and 1500-2500 mm of mean annual precipitation. Temperature is mild in the central part of the plateau. The eastern area has higher elevations and a cold climate with sporadic snowfall during the winter months of June/July.

Four major vegetation types dominate the region including grasslands (Campos), Araucaria forest, semideciduous forest, and the Atlantic tropical forest (Fig. 1). All taxonomic names mentioned below follow Leite and Klein (1990). Campos vegetation dominates the southern lowland portion of the area. Modern highland vegetation is comprised of a mosaic of grasslands and Araucaria forests. Dominant families are the Poaceae, Cyperaceae, Asteraceae, Fabaceae, Caesalpinaceae, and Verbenaceae (Leite and Klein 1990). Araucaria forest is distributed along the states of Rio Grande do Sul, Santa Catarina, Paraná, and São Paulo, but is also present in some areas of Rio de Janeiro and Minas Gerais states, as well as in small areas of Misiones Province, Argentina and Paraguay. The tree, Araucaria angustifolia, commonly known as the Paraná-pine, with its characteristic umbrella shape crown, occurs above 600 m, but becomes more important as a canopy component above 800 m elevation. This species covers large areas between 24° and 30° S at elevations between 600 and 1400 m in southern Brazil, and in isolated islands between 18⁰ and 24⁰ at elevations 1400 to 1800 m in south-eastern Brazil (Hueck 1953; Rambo 1956). A. angustifolia occupies regions with an annual rainfall > 1400 mm, with a minimum average temperature of c. 11.5° C and a maximum temperature of 22° C (Backes 1999). Before its commercial logging, and the expansion of cattle ranching and industrial agriculture in the region, Araucaria forest occupied c. 175,000 km² of the SBHs, but is now reduced to only 3% of its original cover (FUPEF 2001). Araucaria forest is mainly composed of Araucaria angustifolia, Podocarpus lambertii, Ilex paraguayensis, Drymis brasiliensis, Symplocos uniflora, and Mimosa scabrella. Other trees of importance are species in the Myrtaceae (Myrceugenia spp., Eugenia spp., Myrciaria spp.) and Lauraceae (Ocotea spp., Nectandra spp.). The tropical Atlantic forest occurs in southern Brazil as a belt along the Atlantic coastal plain and in the eastern slopes of the plateau at elevations up to 1000 m. The plain is widest near the boarder of Santa Catarina and Rio Grande do Sul states where it is as much as 200 km wide. These forests form one of the biodiversity hotspots recognised by Myers et al. (2000). Dominant trees are in the Euphorbiaceae (Alchornea), Arecaceae (Euterpe),

Sapotaceae (Leite and Klein 1990). The semideciduous forest grows along the Paraná and Uruguay river systems and the southern escarpment of the plateau following the tributaries up to 500-800 m elevation. In the Paraná basin this forest covers an area 100-150 km wide, and is mainly composed of Alchornea triplinerva, Celtis spp., Gallesia, Copaifera langsdorfii, and Hymenea stilbocarpa. **Evidence for Late Holocene vegetation changes**

Myrtaceae, Moraceae, Bignoniaceae, Lauraceae, and

The southern Brazilian highlands have been a major focus of palynological research during the past decade making it one of the most intensely studied regions of South America. Ten pollen cores from the southern Brazilian states of Rio Grande do Sul, Santa Catarina, and Paraná, show marked changes in vegetation in the SBHs beginning at the end of the mid Holocene. During the initial part of the late-Holocene period between around 4480 and 1410 cal. yr BP, the climate became wetter. Consequently, Araucaria forest expanded to form a network of gallery forest along streams, although grassland vegetation dominated at a regional scale. Beginning about 1410-900 cal. yr BP, the climate become even wetter and less seasonal, which resulted in the replacement of grasslands by Araucaria forest in the southern sector of the plateau.

In Paraná State, the fossil pollen record from Serra Campos Gerais (SCG) (1200 m) (Fig. 2), indicates that between 2980 and 1440 cal. yr BP (2850 and 1530 ¹⁴C yr BP) there was a slight increase in Araucaria forest abundance and higher percentages of tropical forest taxa. Behling (1997a) suggested that this was the first expansion of Araucaria forest from valley habitats into the adjacent highlands, while tropical forest tree populations became more extensive in the valleys. These patterns are associated with the highest percentages of charcoal particles detected in this record, an aspect that will be discussed below in more detail.

Between 1440 and 580 cal. yr BP (1530 and 530 14 C vr BP), the pollen record shows a major increase in Araucaria forest and the tropical forest group remains steady. Behling (1997a) indicates that the higher percentages of Araucaria pollen clearly show that the wettest climate, without a significant annual dry season, was only established during this period creating a landscape characterised by a mosaic of open grasslands and Araucaria forest. The charcoal record shows that fires during this period were frequent, but not as common as between 2980 and 1440 cal. yr BP (2850 and 1530 14 C yr BP). In the

highlands of the neighbouring state of São Paulo, the Morro de Itapeva pollen core shows a change to more humid conditions at c. 3200 cal. yr BP (3000^{-14} C yr BP) (Behling 1997b).

In the state of Santa Catarina, at the Serra da Boa Vista core (1160 m) there is an initial increase in Araucaria forest taxa (Araucaria, Podocarpus, Mimosa, Ilex, Symplocos) recorded after c. 3760 cal. yr BP (3460¹⁴C yr BP) (Ledru *et al.* 1998). At Morro da Igreja (1800 m) the pollen sequence show an initial expansion of Araucaria forest at c. 2430 cal. yr BP (2390¹⁴C yr BP). Subsequently, both the Morro da Igreja and the Serra do Rio Rastro (1420 m) fossil pollen records show a pronounced expansion of Araucaria forest as indicated by high percentages of Araucaria pollen and spores of the tree fern Dicksonia sellowiana, which indicate the establishment of more humid climate conditions after c. 900 cal. yr BP (1000 ¹⁴C yr BP) (Fig. 3) (Behling 1995).

Located in the highlands of north-eastern Rio Grande do Sul state, Cambará do Sul (1040 m) provided one of the more recent and well-dated pollen sequences for the region (Fig. 4) (Behling and Pillar 2007; Behling et al. 2004). Similar to the records in the highlands of Paraná and Santa Catarina states, an initial expansion of Araucaria forest, which at that time, formed gallery forests along streams within a landscape dominated by grassland vegetation, was observed around 4320 cal. yr BP (3950¹⁴C yr BP). By that time, the Atlantic forest was well established on the upper coastal slopes, located 6-10 km from the study site. Carbonised particles abruptly increased in abundance during this period.

Between c. 1100 and 430 cal. yr BP (1140 and 410 ¹⁴C yr BP), the representation of Campos pollen taxa, primarily Poaceae, was markedly lower than in the previous period and its abundance continued to decrease toward the top of the zone (from 55 to 24%). Pollen of Araucaria forest increased continuously (from 39 to 80%) indicating a remarkably strong expansion of this forest, such that within a period of 100 years it replaced the Campos vegetation. At c. 1100 cal. yr BP, there were fewer carbonised particles than before, although fires continue to be frequent in the wider region where patches of grassland still existed (Behling et al. 2004).

In the nearby São Francisco de Paula sequence, pollen preservation in deposits started after 4480 cal. yr BP (4000¹⁴C yr BP) indicating wetter climatic conditions (Behling et al. 2001). Here the expansion of Araucaria started at c. 990 cal. yr BP (1060 ¹⁴C yr BP). Other pollen records from the highlands of Rio





Grande do Sul state at Aparados da Serra (1000 m) and three pollen cores in the lowlands including São Francisco de Assis (100 m), Terra de Areia (0 m), and Lagoa dos Patos (0 m) recorded an increase in forest taxa including *Araucaria* and *Podocarpus* after *c*. 2590 cal. yr BP (2500 ¹⁴C yr BP). An expansion of

Araucaria forest on the plateau and of tropical and semidecidous forest along the escarpment indicative of higher moisture and higher temperature, was inferred (Behling *et al.* 2005; Ledru *et al.* 1998). At present the radiocarbon date of *c.* 1100 cal. yr BP from Cambará do Sul is the best date for the pronounced expansion of *Araucaria* forest in the SBHs. Fig. 5 shows *Araucaria angustifolia* pollen curves from most representative pollen sequences discussed in the text.

The change to more humid conditions at around 4480 cal. yr BP (4000 ¹⁴C yr BP) was also recorded in the neighbouring coastal Atlantic tropical forest (e.g., Behling and Negrelle 2001; Bissa *et al.* 2000; Garcia *et al.* 2004; Scheel-Ybert 2000), the cerrados of Central Brazil (Salgado-Labouriau 1997), and the grasslands of south-eastern Brazil (Behling *et al.* 2005) and Uruguay (Iriarte *et al.* 2004; Iriarte 2006a).

In summary, the first Holocene expansion of *Araucaria* forest at the expense of Campos grasslands in the SBHs started between 4480 and 3200 cal. yr BP. A later, greater expansion of *Araucaria* forest began between around 1410 and 900 cal. yr BP. Specifically, this event was dated to *c*. 1100 cal. yr BP in Cambará do Sul, 990 cal. yr BP in São Francisco de Paula in Rio Grande do Sul, 900 cal. yr BP in Morro da Igreja and Serra do Rio Rastro in Santa Catarina and at *c*. 1440 cal. yr BP in the Serra Campos Gerais, Parana State. In the highlands of Paraná, the expansion of *Araucaria* forest resulted in



Figure 4 Cambara do Sul pollen profile (Behling and Pillar 2007)

Serra de Río Ras. 0 1000 2000 3000 4000 \$ 5000 ¹⁴C yr 6000 7000 8000 9000 10000 11000 10 20%

Figure 5 Araucaria angustifolia pollen percentage curves from selected pollen diagrams

a mosaic of grasslands and *Araucaria* forest patches, while in Rio Grande do Sul, grassland vegetation was replaced by *Araucaria* forest.

The Taquara/Itararé Tradition

First defined by Menghin (1957) as El Doradense in Misiones Province, this archaeological tradition is known as Itararé in Paraná (Chmyz 1967) and Taquara in Santa Catarina and Rio Grande do Sul states (Miller 1967). Following Beber (2004), we use the term Taguara/Itararé Tradition for the sake of convenience. Dating back to c. 2220 cal. yr BP (2180 ¹⁴C yr BP) and extending to present, this broadlydefined tradition, is mainly characterised for its diagnostic ceramics, the construction of pithouses in the highlands, and its elaborated mound and enclosure complexes. The brief summary and the compilation of radiocarbon dates presented below has been obtained from data published by Brazilian researchers over the last decades (Beber 2004; 2005; De Masi 2005; Noelli 2000; Prous 1992; Ribeiro

1999/2000; Schmitz 1988; 1999/2000; Schmitz 2002). The reader is referred to these works for more detailed information.

Taquara/Itararé ceramics are characterised by simple, tall, small vessels exhibiting fine walls. They are generally tempered with sand and hematite grains, have homogenous paste, and reduced firing. Decoration is more frequent in the southern Taquara phases and includes several incised types, punctuations, as well as finger nail and basket impressions. The economy of these groups is thought to be based mainly on the exploitation of *Araucaria* seeds complemented with horticulture, hunting, and fishing (Beber 2005; Ribeiro 1999/2000; Schmitz 2001/2002).

Five types of archaeological sites are associated with the Taquara/Itararé Tradition including pithouses, open air sites, geometric earthworks and mounds, caves and galleries. Generally constructed on lateritic soils and decomposed basalt, pithouses occur above 400 m, but are concentrated between 600-1200 m elevation closely overlapping the distribution of Araucaria forest. Pithouses are generally located in the upper slope and flat tops of interfluvial ridges close to small streams. The diameter of a pithouse ranges between 2 m and 20 m, but the majority do not exceed 5 m. Pithouses are habitation sites containing the remains of everyday activities including hearths, post-holes, ceramic sherds, lithic tools and debris, and charred Araucaria seeds (Fig. 6) (Beber 2005; Ribeiro 1999/2000; Schmitz 1988). The tough, double-coated Araucaria seeds, which bear a first hard layer surrounding the seed that accounts for 22% of the seed's dry weight (Bello-Perez et al. 2006; Cordenunsi et al. 2004), have been the only charred macro-botanical remains recovered in pithouses. Pithouses may be isolated or form villages of up to 68 houses. The ground plan of pithouse villages may exhibit a linear layout paralleling a stream, may be arranged in parallel lines, or form an approximate circle (Prous 1992: 313). Surface sites associated with pithouse clusters are common and have been interpreted as probable special-activity areas such as agricultural plots and quarry sites (e.g., Beber 2005; De Masi 2005; Kern et al. 1989; Ribeiro and Ribeiro 1985).

At lower altitudes, in the upper river valleys and the southern escarpment of the plateau where *Araucaria* forest is sparser and semidecidous forest dominates, pithouses become rare and surface sites are more abundant. In some areas like the lower Antas and Pardo rivers, situated below 600 m elevation, Taquara/Itararé surface sites are characterised



Figure 6 Sketch diagram of a pithouses (La Salvia 1983)

by discrete circular patches of dark earth (*terra preta*) forming villages that cover up to 4000 m^2 (Miller 1967, 20; Ribeiro 1991 cited in Beber 2004).

Other types of site associated with Taquara/Itararé Tradition were characterised by circular, elliptical, rectangular, and key-shape earthworks generally located in the most prominent hills of the area. The rims were 30-50 cm tall, 3-4 m wide, and 20-200 m in diameter. Their formal layout and lack of domestic debris indicate that these sites were ceremonial spaces where geographically dispersed groups came together to bury an important chief, host inter-group gatherings, foster group reciprocity, forge inter-group alliances or perform cyclical rituals (Beber 2005; Cope and Saldanha 2002; Schmitz and Becker 1991). Some of them, like the complex of earthworks in El Dorado (Misiones, Argentina) spread over 200 ha and are constituted by more than 8 circular enclosures (Menghin 1957; Wachnitz 1984). On-going excavations by Iriante and colleagnes in the larger of these mound and enclosure centres are revealing a complex history of construction stages and use spanning between 703-518 cal. yr BP, some of which appear to have dramatically altered the appearance of the enclosure and its associated mound. Two other types of site have been associated with the Taquara/Itararé people: collective burials in caves, and galleries of unknown use dug into consolidated soils (Rohr 1971).

Human-environment interactions in the southern Brazilian highlands: the last 1500 years

The development of the Taquara/Itararé tradition and the expansion of Araucaria forest

Some important patterns emerged from the comparison of the recent palynological and archaeological

data from the SBHs. In the first place, the data showed that the colonisation of the SBH by the Taquara/Itararé Tradition was strongly associated with the marked expansion of Araucaria forest during the late Holocene. The available 71 radiocarbon dates indicated that Taquara/Itararé sites began to spread in the second millennium BP, became more common around 1500 cal. yr BP and peaked after 1000 cal. yr BP (Table 1, Fig. 7). This pattern was also supported by plotting the best-dated sequences from the clusters of pithouses that occurred in the north-east of Rio Grande do Sul state (Esmeralda, Vacaria, Bom Jesus, and São Francisco de Paula) against the Araucaria pollen percentage changes from the nearby Cambará do Sul pollen site (see Figs. 1 and 8). From the 33 existing radiocarbon dates of pithouses for this region, 79% of the dates are younger than 1000 cal. yr BP, 15% lie between 1500 and 1000 cal. yr BP, and the remaining 6% of dates are older than c. 1500 cal. yr BP (Fig. 8).

As *Araucaria* forest began to expand in the highlands, pre-Hispanic groups may have been motivated to migrate or foray seasonally to the highlands to collect *Araucaria* seeds in areas of concentrated production. The replacement of grassland by *Araucaria* forest that took place between 1410 and 900 cal. yr BP (1500 and 1000 ¹⁴C yr BP) may have allowed higher permanent settlement in the highlands. The cultural development adapted to this new environment is inferred based upon the proliferation of Taquara/Itararé pithouse villages. Sites located within ecotones comprised by *Araucaria* forest, Campos, and deciduous forests, would have been privileged locations in terms of abundance and diversity of resources.



Taquara/Itarare dates from northeastern Rio Grande do Sul



Araucaria seeds, called pinhão, were a major element in the diet of the ethnohistorically and ethnographically recorded indigenous people living in and around the range of the *Araucaria* trees (Mabilde 1988; Metraux 1946). *Araucaria* trees are very productive. Each tree produces up to thirty large cones, each of which contains an average of 112 seeds (5.8 cm long) (FAO 1995). Unfortunately, we do not posses data about the modern density of *Araucaria* trees in different regions, but the pollen data suggest that they were very abundant in the SBH since *c*. 1410–900 cal. yr BP (1500–1000 ¹⁴C yr BP). Araucaria seeds are a good source of starch (37%), dietary fibre, Mg, and Cu. They also have a low content of protein (~3%) and lipids (~1·3%), which is comparable to other starchy foods such as rice and beans (Bello-Perez *et al.* 2006; Cordenunsi *et al.* 2004). The seeds are mainly harvested during the months of March and June, but production is meagre during the spring and summer (October–February). However, the seeds of different subspecies of *Araucaria angustifolia* are ripe during different months of the year, which potentially make them available all year round (Beber 2005; Reitz and Klein

Table 1 Taquara/Itararé Tradition dates from Riogrande do Sul (RS), Santa Catalina (SC) and Parana (PR) states. The calibration of the radiocarbon dates have been carried out after CALPAL (Weninger et al. 2004)

Site Locality Lab no. yr BP cal BP age cal. BP Reteraces RS-A-27 Vicaria, RS Beta 14/246 30 ±00 148-31 59 ±99 Schmitz et al. 2002 RS-M-20 Vicaria, RS Beta 16/6666 00 ± 50 228-37 128 ±106 Cope and Salarha 2002 RS-W-24 TerrentP Fortela, RS S1699 205 ±100 427-106 286 ±179 Crurv Mathadaha 2002 RS-W-24 TerrentP Fortela, RS S1697 330 ±90 471-324 808 ±87 Schmitz et al. 2002 SC-0L-10 Urubici, SC S1597 330 ±90 471-344 408 ±66 Reternorand Riberio 1385 RS-A-29 Vicaria, RS S16966 330 ±90 471-344 448 ±66 Cope and Salarha 2002 RS-A-29 Vicaria, RS S16566 330 ±90 474-341 441 ±69 Cope and Salarha 2002 RS-A-29 Vicaria, RS S16562 420 ±55 510 358 434 ±76 Riberio and Riberio 1385 RS-A-29 Vicaria, RS S16562 420 ±55 510 356 <th colspan="2">Provenance</th> <th></th> <th>¹⁴C age</th> <th>64% range</th> <th>Calendric</th> <th></th>	Provenance			¹⁴ C age	64% range	Calendric	
PEA-27 Vacaria, RS Beta 14/2/6 0 ± 50 148-31 69 ± 69 Schmitz <i>et al.</i> 2002 RS-AV.20 Vacaria, RS Beta 166566 00 ± 50 227-23 126 ± 106 Cope and Salana 2002 RS-V2-44 Tenerle Portela, RS S1692 225 ± 100 427-140 266 ± 169 Chymz 1999 Tora de Padra, SP Gay 270 ± 106 427-140 266 ± 169 Chymz 1999 SC-L10 Urubici, SC S1 597 330 ± 90 471 ± 246 384 ± 67 Schmitz 1986 RS-A23 Vacaria, RS Beta 166544 370 ± 50 483-345 414 ± 69 Cope and Salana 2002 RS-A29 Vacaria, RS Beta 166544 370 ± 50 483-345 417 ± 72 Schmitz 94 ± 002 RS-A29 Vacaria, RS S1 600 400 ± 105 514-346 443 ± 49 Robits 1085 RS-A29 Vacaria, RS S1 600 400 ± 105 514-346 443 ± 49 Robits 1085 RS-A29 Vacaria, RS S1 600 520 ± 40 643-555 717 F166 tona R	Site	Locality	Lab no.	yr BP	cal BP	age cal. BP	References
BSA-X2 Vacaria, RS Beta 144/243 40±00 227-23 102±125 Schmitz Cope and Saldanha 2002 RS-VA-VA Tenente Porteia, RS B1 990 100±70 2267-37 15±114 Miller 1971 CLU Machado, RS S1 990 100±70 2267-37 15±114 Miller 1971 CLU Machado, RS S1 990 2255±100 424-100 309±118 Deslass 1980 CC-CL-101, SC S1 997 305±10 474-534 414±69 Cope and Saldanha 2002 RS-A-20 Vacaria, RS Beta 16654 370±50 483-345 414±69 Cope and Saldanha 2002 RS-A-29 Vacaria, RS Beta 15334 30±50 489-345 412±72 Schmitz and Ribero 1985 RS-22-29 Vacaria, RS S1 6556 300±50 494-350 412±72 Schmitz and Ribero 1985 RS-72-25 Porto Lucema, RS S1 6558 420±55 510:38 484±76 Ribero and Ribero 1985 RS-40-3 Rom Jesus, RS Beta 144245 520±60 682±40 Corpura 1995	RS-A-27	Vacaria, RS	Beta 144246	30 ± 50	148–31	59±89	Schmitz et al. 2002
FR-M-N03 Born Jesus, R5 Beta 166556 80+50 225 17 126±106 Corpe and Biddenha 2002 SV-244 Tenrite Portela, R5 Si 662 255±100 424+106 256±150 Chym. 1969 SC-CL-10 Urubici, SC Si 662 325±100 424+106 256±150 Chym. 1969 SC-CL-10 Urubici, SC Si 667 330±90 471±344 448±167 Schmitz 1988 SR-A49 Yourain, R5 Beta 176089 370±50 474±344 414±69 Compared R10400 SR-A59 Yourain, R5 Beta 176089 370±50 483±34 414±69 Schmitz et al. 2002 SR-A59 Yourain, R5 Beta 176086 300±100 430±30 422±72 Nibiero and Ribeiro 1985 SR-A57 Youraina, R5 Beta 166585 550±40 652±30 571±51 Schmitz et al. 2002 SR-A72 Youraina, R5 Beta 166585 550±40 662±30 571±51 Schmitz et al. 2002 SR-A72 Youraina, R5 Beta 166585 550±40 643±56	RS-A-27	Vacaria, RS	Beta 144243	40 ± 60	227–23	102±125	Schmitz <i>et al</i> . 2002
Fis-V2-4t Tenente Portela. RS SI 599 110-1/20 226 7 37 151±114 Miller 1971 Cuz Machado, PR SI 692 256±100 474-100 300±118 Deflassi 1946 SC-0L-10 Unitobici, SC SI 547 300±04 471-296 304±457 Schmitz 1968 RS-RE-10b Esmaralda, RS Beta 15054 300±50 443±456 Albeina and Ribelino 1985 RS-A2 Vacana, RS Beta 15054 300±50 483-345 414±69 Roge 2005 RS-A2 Vacana, RS Beta 15054 300±50 483-345 422±57 Hibbein and Ribein 1985 RS-A2 Vacana, RS Stope 4552 420±25 510±36 43±75 Hibbein and Ribein 1985 RS-A2 Nacana, RS Beta 144245 520±40 625±20 571±51 Schmitz 1986 RS-A2 Nacana, RS Beta 144245 520±40 625±45 599±44 Chmy 2196 RS-A3 Som Lesus, RS Beta 144245 520±40 635±49 Schmitz 1998 RS-A3 Som	RS-AN-03	Bom Jesus, RS	Beta 166586	80 ± 50	235–17	126 ± 106	Cope and Saldanha 2002
Chuz Machado, FP SI 692 255 ± 100 424-106 285 ± 159 Churm 1969 SC-0L-10 Urubici, SC SI 697 330 ± 90 477-396 346 ± 67 Schmitz 1988 RS-PL-10 Emeralda, RS SI 6639 355 ± 60 443-345 414 ± 69 Cope and RS aldarina 2002 RS-A-29 Vacaria, RS Beta 15383 300 ± 60 433-345 414 ± 69 Cope and RS aldarina 2002 RS-A-29 Vacaria, RS Beta 15383 300 ± 60 434-350 417 ± 71 Schmitz 40 2002 RS-A-29 Vacaria, RS SI 6560 300 ± 60 434-450 412 ± 72 Schmitz 40 2002 RS-F2:80 Emeralda, RS SI 6562 420 ± 25 510 ± 38 43 ± 76 Ribaria and Ribaria 1985 RS-F2:80 Emeralda, RS SI 6562 420 ± 26 631 ± 51 60 471 ± 51 Ribaria and Ribaria 1985 RS-F2:80 Emeralda, RS SI 6562 450 ± 45 59 ± 44 Cope and Ribaria 1986 RS-F2:80 Emeralda, RS SI 666 505 ± 46 <td>RS-VZ-44</td> <td>Tenente Portela, RS</td> <td>SI 599</td> <td>160 ± 70</td> <td>267–37</td> <td>151 ± 114</td> <td>Miller 1971</td>	RS-VZ-44	Tenente Portela, RS	SI 599	160 ± 70	267–37	151 ± 114	Miller 1971
Torre de Pedra, SP Gsy 270_±00 427-190 309-116 Deflassi 1996 RS-PE-100 Emmeralda, RS Bit 658 370_±50 443_444 440_±66 Riberro and Riberro 1985 RS-APL-00 Emmeralda, RS Beta 15034 330_±50 443_434 414_±93 Roge 2005 RS-A2.20 Vacaria, RS Beta 15034 330_±50 443_434 417_±72 Schmitz 214 2002 RS-A2.20 Esmeralda, RS Si 6564 402_±55 510_358 422_±76 Riberio and Riberio 1985 RS-PE-0a Esmeralda, RS Si 6564 462_±40 515_±17 Riberio and Riberio 1985 RS-PLIB-4 Univeria, PR Si 16586 562_±00 631_±41 566_±5 Corpo and Saldanha 2002 PR-C1-38 Campo Largo, PR Beta 142245 568_±50 631_±41 566_±6 Chmy 1976 PR-C1-38 Campo Largo, PR Beta 22646 568_±50 631_±41 566_±6 Chmy 214_2003 PR-C1-38 Campo Largo, PR Beta 22646 568_±50 643_±56 560		Cruz Machado, PR	SI 692	255 <u>+</u> 100	424–106	265 <u>+</u> 159	Chymz 1969
SC-C1-10 Urubici, SC S1 697 330.90 471-286 Riberio and Riberio 1985 RS-PH-100 Bernraida, RS Beta 16654 370.50 483.345 414±68 Ropa and Saltanna 2002 RS-A29 Vacaria, RS Beta 178089 370.50 483.345 414±68 Ropa and Saltanna 2002 RS-A29 Vacaria, RS Beta 178089 370.50 422.172 Riberio and Riberio 1985 RS-F2:05 Bernraida, RS S1 656 330.46 422.189 Millerior 1985 RS-F2:10 Bernraida, RS S1 6554 465.40 512.334 422.189 Millerior 1985 RS-F2:10 Bernraida, RS S1 6555 463.41 626.520 571.151 S0mm/seus, RS RS-A4:3 Born Jasus, RS Beta 146265 530.540 539.540 539.544 Cope and Saltanna 2002 RS-A4:3 Born Jasus, RS Beta 160665 530.540 539.544 Cope and Saltanna 2002 RS-A4:3 Born Jasus, RS Beta 160665 530.544 Cope and Saltanna 2002 RS-A4:4 Born J		Torre de Pedra, SP	Gsy	270 ± 60	427–190	309±118	DeBlasis 1996
RS-PE-100 Esmeralda, RS SI 6559 355 ±50 474-341 408±66 Robuston and Riberio 1985 RS-Av-29 Vacaria, RS Beta 178069 370±50 483-345 411±69 Roge 2005 RS-A29 Vacaria, RS Beta 178069 370±50 483-345 411±69 Roge 2005 RS-PE-100 Esmeralda, RS SI 6556 300±50 494-350 422±72 Riberio and Riberio 1985 RS-PE-100 Esmeralda, RS SI 6556 420±55 510=356 433±76 Riberio and Riberio 1985 RS-PE-208 Esmeralda, RS Beta 146245 520±60 511±17 Riberio and Riberio 1985 RS-Av2 Xacaria, RS Beta 146245 520±60 561±11 562±64 Charpa and Saldanha 2002 RS-Av3 Xacaria, RS Beta 126065 550±440 625:55 582±44 Charpa and Saldanha 2002 RS-Av2 Xacaria, RS Beta 126065 580±546 601±72 Chriny 1985 RS-Av2 Xacaria, RS Beta 12606 583±54 Chriny 1986 Chriny 1986	SC-CL-10	Urubici, SC	SI 597	330 ± 90	471–296	384 ± 87	Schmitz 1988
RS-A.20 Yacaria, RS Beta 166584 370±50 483:345 411±69 Coga and Saldanha 2002 RSA-29 Vacaria, RS Beta 15834 380±0 489:345 411±72 Schmitz et al. 2002 RSP-E100 Esmeralda, RS S1656 380±0 489:345 411±77 Schmitz et al. 2002 RS-22 Porto Lucena, RS S1656 300±10 512:334 422±89 Millerio 1985 RSP-E20a Esmeralda, RS S16558 405±45 510 532-498 511±17 Ribeiro and Ribeiro 1985 RS-A-7 Vacaria, RS Beta 144245 520±00 662-520 571±61 Schmitz et al. 2002 RS-A-7 Vacaria, RS Beta 16665 550±0 641-555 591±44 Cope and Saldanha 2002 PR-OT-33 Campo Largo, PR Beta 22646 585±0 641-556 600±14 Comput al 2003 PR-OT-33 Camita, RS Beta 146245 520±64 662+520 671±26 Comput al 2003 PR-OT-33 Camita, RS Bota 166655 500±44 Commy	RS-PE-10b	Esmeralda, RS	SI 6559	355 ± 50	474–341	408 ± 66	Ribeiro and Ribeiro 1985
RSA-29 Vacaria, RS Beta 178089 370±0 483-345 411±69 Poge 2005 RS-PE-10b Esmeralda, RS Bits 15383 380±50 442±72 Ribmic and Ribeiro 1985 RS-PE-10b Esmeralda, RS S16556 390±50 444.350 422±72 Ribeiro and Ribeiro 1985 RS-PE-10a Esmeralda, RS S16558 452±105 532+347 Ribeiro and Ribeiro 1985 RS-PE-10a Esmeralda, RS S16558 452±10 S12+107 Ribeiro and Ribeiro 1985 RS-A27 Vacaria, RS Beta 16658 550±40 628-538 S82±44 Comput 1976 RS-A27 Vacaria, RS Beta 126266 558±0 643-555 599±44 Chrmyz et al 2003 RS-A29 Vacaria, RS S1636 550±10 641-558 601±70 Risis 1996 PR-U-V12 Unituona, RS S1636 550±120 673-584 601±17 Risis 1996 RS-C12 S363 S45±120 673-584 601±17 Risis 1996 RS-C12 S636 Sbasto ob Ca, RS	RS-AN-03	Bom Jesus, RS	Beta 166584	370 ± 50	483–345	414 ± 69	Cope and Saldanha 2002
RSA-29 Vacaria, RS Beta 15383 380±0 489=345 417±72 Schmitter at J.2002 RSV-E20 Barmeralda, RS SI 600 400±100 512-334 422±89 Milerior and Ribeiro 1985 RSV-E22 Porto Lucena, RS SI 6558 340±75 512-334 422±89 Milerior and Ribeiro 1985 RSP-E20a Esmeralda, RS SI 6558 465±40 532-438 512±17 Ribeiro and Ribeiro 1985 RSA-7 Vacaria, RS Beta 144245 520±00 662-520 571±51 Schmitz et al. 2002 RSA-7 Vacaria, RS Beta 166685 500±40 663-555 599±44 Corpor and Salidanha 2002 PR-T-733 Curriloa, PR Beta 22646 585±0 641-556 600±72 Chrnyz et al 2003 PR-TV-12 Curuiba, PR Beta 22646 585±0 641-556 600±74 Deslasis 1996 Sirior da Seara GSI, RS Si 639 662-520 671±74 Deslasis 1906 Sirior da Seara GSI, RS Si 639 640±170 655-64 611±77 <td>RS-A-29</td> <td>Vacaria, RS</td> <td>Beta 178089</td> <td>370 ± 50</td> <td>483–345</td> <td>414 ± 69</td> <td>Rogge 2005</td>	RS-A-29	Vacaria, RS	Beta 178089	370 ± 50	483–345	414 ± 69	Rogge 2005
RS-PE-10b Esmeralda, RS SI 6656 390_±50 494_350 422±72 Riberio and Riberio 1985 RS-PE-22a Esmeralda, RS SI 6662 420_±55 510_358 434±76 Riberio and Riberio 1985 RS-PE-10a Esmeralda, RS SI 6652 420_±55 594_375 485±109 Miller 1971 RS-Av3 Vacaria, RS Beta 142425 502±00 662-530 571±151 Schmiz 14 2002 RS-Av3 Born Jesus, RS Beta 142425 550±40 628-533 582±44 Chmyz 1995 PR-CT-33 Curitiba, PR Beta 126685 550±40 633-549 594±44 Chmyz et al 2003 BS19 Bairo da Serra Gay 10040 555±120 673-552 601±41 Deltasis 1996 PLV-12 Curitiba, PR SI 608 620±90 662-554 608±143 Schmizt 1988 RS-612 Si Sobastibo oCa, RS SI 604 630±70 667-564 611±47 Schmizt 1988 RS-722 So Sobastibo oCa, RS SI 6561 655±455 651-572 617±44<	RS-A-29	Vacaria, RS	Beta 153834	380 ± 60	489–345	417 <u>+</u> 72	Schmitz et al. 2002
HS-V2.22 Porto Luceria, HS S1 600 400 ±100 512-334 423 ±99 Miller 1971 RS-PE-10a Esmeralda, RS S1 6652 402 ±55 510-358 434 ±76 Ribeiro and Ribeiro 1985 RS-PE-10a Esmeralda, RS S1 6652 400 ±50 515 ±17 Ribeiro and Ribeiro 1985 RS-A27 Vacaria, RS Beta 144245 520 ±00 662-520 571 ±51 Schmitz <i>et al</i> 2002 RS-AX-3 Bom Jesus, RS Beta 166685 500 ±00 633-541 566 ±44 Chmyz 1995 PR-CT-30 Curitiba, PR Beta 22646 558 ±50 641-558 601 ±12 Chmyz 1995 PR-MV-41 Middle Juguzu River, PR S1 6396 595 ±50 641 ±53 500 ±141 DeBlasis 1996 PR-1V-12 Cruz Machado, PR S1 601 603 ±10 687-540 614 ±73 Schmitz 1988 PR-47-42 Savais do Sul, RS S1 601 603 ±10 687-546 611 ±74 Ribeiro and Ribeiro 1985 PR-47-43 Curitiba, PR Beta 130000 661 ±70 644 ±73	RS-PE-10b	Esmeralda, RS	SI 6556	390 ± 50	494-350	422 ± 72	Ribeiro and Ribeiro 1985
HS-P-E28a Esmeralda, RS SI 6662 420 ±52 434 ±76 Hiberio and Hiberio 1985 PR-UB4 Ubirată, PR Bita 16658 465 ±40 532-439 515-171 Hiberio and Hiberio 1985 PR-UB4 Ubirată, PR Bita 146265 500-400 662-520 571-1151 Schmitz et al. 2002 RS-AN-3 Bom Jesus, RS Beta 146265 550-40 628-536 552-244 Chmyz 1995 PR-OT-33 Curitba, PR Beta 126065 580+±0 633-549 594+±45 Chmyz 1995 PR-U-742 Curitba, PR St 6396 595+±0 643-555 599+±44 Chmyz 1996 RS-88 Caxias do Sul, RS St 608 620+±120 677-524 601±47 Schmitz 1988 RS-012 Sa Sobastiao ota, IRS St 604 630-±70 687-564 611±47 Schmitz 1988 RS-012 Sa Sobastiao ota, IRS St 6051 660+572 672+44 Hiberio and Ribeiro 1985 RS-429 Vacata, RS St 6651 630+±576 630+±54	RS-VZ-25	Porto Lucena, RS	SI 600	400 ± 100	512-334	423 ± 89	Miller 1971
HS-HE-101a Esmeratida, HS S165:81 Holero and Holero 1985 PH-UB4 Ubirata, PR S12192 477.495 594-375 485.109 Chmyz 1976 RS-A:27 Vacaria, RS Beta 144245 520.400 662-520 571.±51 Schmitz <i>et al.</i> 2002 PR-CT-33 Campo Largo, PR Beta 126665 550.440 626-535 552.444 Cope and Suldanha 2002 PR-T-33 Curitba, PR Beta 126065 550.450 643-555 599.±44 Chmyz et al 2003 BS19 Bairro da Serra Gsy 10040 552.±50 641-558 601±122 Chmyz et al 2003 BS-68 Caxias ot 504, PS S 1601 602.±20 673-528 601±122 Chmyz 1969 PR-1V-12 Bituruna, RS S 1601 623.±20 673-548 611±72 Chmyz 1969 PR-27-30 Curitba, PR Beta 180040 660±70 674-544 613±178 f050±00 RS-72-28 Semeratida, RS S 10563 650±70 667±64 Chmyz et al.2003 RS-72-30 Curi	RS-PE-28a	Esmeralda, RS	SI 6562	420 ± 55	510-358	434 ± 76	Ribeiro and Ribeiro 1985
PH-UB-4 Ubirata, PH SI 2192 47(1)=95 594-3/5 48b±109 Chmyz 19/6 RS-Av2 Vacaria, RS Beta 144245 550±40 626-520 571±51 Schmitz et al. 2002 RS-Av3 Born Jesus, RS Beta 146245 550±40 626-520 571±51 Schmitz et al. 2002 PR-CT-33 Curitba, PR Beta 22646 639-549 594±45 Chmyz et al. 2003 PR-MN-4 Middle Jguzzu River, PR Bita 6396 580±60 641-558 600±172 Chymy 1996 PR-W-4 Caxias do Sul, RS S 1691 623±120 662-554 608±54 Schmitz 1988 RS-6712 Caxias do Sul, RS S 1691 632±120 662-554 608±54 Schmitz 1988 RS-7127 Caxias do Sul, RS S 1656 631-541 563-571 611±47 Ribeiro and Ribeiro 1985 RS-72-28 Esmeralda, RS S 1656 635±56 661-573 630±46 Chmyz 141 Rubeiro and Ribeiro 1985 RS-72-28 Semeralda, RS S 1656 635±56 641-574	RS-PE-10a	Esmeralda, RS	SI 6558	465 ± 40	532-498	515 ± 17	Ribeiro and Ribeiro 1985
HS-A2/ Vacara, HS Befa 1424b 521±60 682-521 571±51 Schmitz et al. 2002 PR-CT-33 Campo Largo, PR Beta 26645 559±44 Cope and Saldanha 2002 PR-CT-33 Campo Largo, PR Beta 180905 559±64 Chmyz tal 2003 PR-MM-4 Middle Jguazu River, PR S1 6396 559±50 643-555 599±44 Cohe yz tal 2003 PR-MM-4 Middle Jguazu River, PR S1 630 555±50 641-558 600±171 Deflasis 1996 PR-MM-4 Middle Jguazu River, PR S1 631 655±50 661±57 Chymz 1969 PR-MV-12 Cruz Machado, PR S1 691 652±70 657-564 611±47 Schmitz 1988 PR-C7-93 Curitba, PR S1 651 635±55 661-572 617±44 Ribeiro 1985 PR-C7-93 Curitba, PR Beta 180906 660±50 666-573 62±44 Cohe of the in 1985 PR-UV-11 Curz Machado, PR S1 1010 680±70 684-576 630±54 Chmyz 1969 PR-UV-12 Curz Machado, P	PR-UB-4	Ubirată, PR	SI 2192	$4/0 \pm 95$	594-375	485 ± 109	Chmyz 1976
HS-AN-3 Born Jesus, HS Befa 106945 Sb1±40 628-538 582±44 Chope and Saldanna 2002 PH-CT-93 Curitba, PR Beta 22646 639-549 594±45 Chmyz et al 2003 PH-CT-93 Curitba, PR Beta 180905 589±60 643-555 599±44 Chmyz et al 2003 BS19 Bairro da Serra Gsy 10040 595±60 641-558 600±11 Chymy 2 et al 2003 RS-68 Caxias do Sul, RS S1 691 620±90 662-554 609±54 Schwy 1969 RS-672 Sab Sebastion do Cai, RS S1 604 630±70 657-564 611±47 Schwitz 1988 RS-672 Sab Sebastion do Cai, RS S1 625 661-573 662+54 662+574 612±41 Robero and Ribeiro 1885 RS-672 Sab Sebastion do Cai, RS S1 6056 661-573 663±54 Chymy 2 et al 2003 FP4-CF43 Chymr 2 et al 2003	RS-A-27	Vacaria, RS	Beta 144245	520 ± 60	662-520	$5/1\pm51$	Schmitz et al. 2002
PH-C1-33 Campo Largo, PH Befa 120905 S89 ± 40 Chmyz et al 2003 PR-CT-34 Middle Iguazu River, PR SI 6396 S95 ± 60 643-555 S99 ± 44 Chmyz et al 2003 BS19 Bairro da Serra Gay 10040 S95 ± 50 641-558 600 ± 41 DeBlasis 1996 PR-UV-12 Cruz Machado, PR SI 691 605 ± 51 673-528 601 ± 72 Chrmz 1969 S6-86 Caxias do Sul, RS SI 691 623 ± 51 673-540 614 ± 73 Schmitz 1988 RS-7L-22 São Sebastiao do Cal, RS SI 605 630 ± 205 791-434 613 ± 178 Rogge 2005 RS-FE-28a Esmeralda, RS SI 6561 633 ± 45 653-571 612 ± 41 Riberio and Riberio 1985 PR-CT-33 Curitiba, PR Beta 130907 684 ± 76 630 ± 54 Chrmyz 1989 PR-CT-34 Curitiba, PR Beta 130907 684 ± 76 630 ± 54 Chrmyz 1980 PR-CT-34 Curitiba, RR Beta 130907 684 ± 76 772 ± 54 Chrmyz 1981 PR-UV-12	RS-AN-3	Bom Jesus, RS	Beta 166585	550 ± 40	626-538	582 ± 44	Cope and Saldanha 2002
PH-C1-93 Curitba, PH Beta 180905 Sb91_40 Chmyz et al 2003 BS19 Bairro da Serra Gsy 10040 Sb91_60 G43-555 Sb91_44 Lbmyz et al 2003 BS19 Bairro da Serra Gsy 10040 Sb91_60 G73-528 G01_172 Chrmz 1969 RS-68 Caxias do Sul, RS SI 608 623_190 662-554 608_143 Schimtz 1988 RS-67.12 Sao Sebastiao do Cal, RS SI 604 630_270 657-564 611_24 Roleino and Ribeiro 1985 RS-FE-26a Esmeralda, RS SI 6561 G53-571 6171_44 Ribeiro and Ribeiro 1985 RS-FE-28a Esmeralda, RS SI 6566 G61_572 6171_44 Ribeiro and Ribeiro 1985 RS-A-29 Vacaria, RS SI 6100 680_170 684-576 G30_454 Chymz 1969 RS-A-29 Vacaria, RS Beta 180907 710_460 694-582 684±56 Schmitz 1988 RS-A-29 Vacaria, RS Beta 170090 710±60 772-596 645±60 in Rogge 2005 RS-A-29V	PR-CI-53	Campo Largo, PR	Beta 22646	558 ± 50	631-541	586 ± 45	Chmyz 1995
PH-MIN4 Middle [guaz] Hiver, PH S16 336 395 ± 60 644-555 395 ± 40 Chmy2 et al 2003 BS19 Bairro da Serra Gsy 10040 695 ± 50 673-528 601 ± 71 Cellasis 1996 PR-UV-12 Cruz Machado, PR S1 691 602 ± 120 673-528 601 ± 72 Chymz 1969 PR-UV-12 Sau Sebastiao do Cal, RS S1 691 623 ± 120 687-540 614 ± 73 Schmitz 1988 RS-712 Sau Sebastiao do Cal, RS S1 605 630 ± 205 791-434 613 ± 178 Rogge 2005 RS-PE-28a Esmeralda, RS S1 6561 635 ± 55 661 = 572 617 ± 44 Ribeiro and Ribeiro 1985 RS-703 Curitiba, PR Beta 150906 660 ± 60 668-573 620 ± 46 Chmyz et al 2003 RS-A29 Vacaria, RS Beta 15342 680 ± 70 684-576 630 ± 54 Chmyz et al 2002 RS-A29 Vacaria, RS Beta 15342 700 ± 60 694 - 582 638 ± 56 Schmitz 1988 RS-A29 Vacaria, RS Beta 17009 710 ± 60 <td>PR-CI-93</td> <td>Curitiba, PR</td> <td>Beta 180905</td> <td>580 ± 60</td> <td>639–549</td> <td>594 ± 45</td> <td>Chmyz et al 2003</td>	PR-CI-93	Curitiba, PR	Beta 180905	580 ± 60	639–549	594 ± 45	Chmyz et al 2003
BS19 Barro da Serra Gay 10040 S99_E-00 641-556 6001_212 Chymz 1969 RS-68 Caxias do Sul, RS S1 691 605_120 662-554 601_272 Chymz 1969 RS-68 Caxias do Sul, RS S1 691 622_1120 662-554 601_274 Schintz 1988 RS-712 Caxias do Sul, RS S1 691 632_120 687-540 611_2_41 Ribeiro and Ribeiro 1985 RS-72-12 São Sebastiao do Cal, RS S1 6561 635_255 661-572 617_2 44 Ribeiro and Ribeiro 1985 RS-PE-26a Esmeralda, RS S1 6563 650_155 661-572 617_2 44 Ribeiro and Ribeiro 1985 RS-A29 Vacaria, RS Beta 130907 684-576 630_254 Chymz 1969 RS-A29 Vacaria, RS Beta 137009 700_160 694-582 638_156 Schmitz 1988 RS-A29 Vacaria, RS Beta 170090 710_160 772-596 638_156 Schmitz 1989 RS-A29 Vacaria, RS Beta 170090 710_160 772-596 648_188	PR-MN-4	Middle Iguazu River, PR	SI 6396	595 ± 60	643-555	599 ± 44	Chmyz et al 2003
PH-UV-12 Cruz Machado, PH Si 691 609±120 673-528 601±22 Chymz 1969 PR-UV-12 Biluruna, RS Si 608 621±90 662-540 661±24 73 Schimtz 1988 PR-UV-12 Caxias do Sul, RS Si 604 639±70 667-540 611±46 Schimtz 1988 PS-271/27 Caxias do Sul, RS Si 6561 635±55 661-572 617±44 Ribeiro and Ribeiro 1985 RS-PE-26a Esmeralda, RS Si 6563 650±55 661-572 617±44 Ribeiro and Ribeiro 1985 PR-CP-33 Curitiba, PR Beta 18090 680±70 684-576 630±54 Chrymz 1989 PR-CP-33 Curitiba, PR Beta 180907 680±70 684-576 630±54 Chrymz 1986 RS-A-29 Vacaria, RS Beta 15342 680±80 635±59 Schmitz 1988 Schmitz 1988 RS-4-29 Vacaria, RS Beta 17809 710±60 705-585 685±60 Schmitz 1988 RS-4-29 Vacaria, RS Bita 178 Si 295 772-596 <t< td=""><td>BS19</td><td>Bairro da Serra</td><td>Gsy 10040</td><td>595 ± 50</td><td>641-558</td><td>600 ± 41</td><td>DeBlasis 1996</td></t<>	BS19	Bairro da Serra	Gsy 10040	595 ± 50	641-558	600 ± 41	DeBlasis 1996
HS-88 Caxas do Sul, HS S fold 622 ±90 662-554 6614 ±73 Schmitz 1986 RS-37/127 Caxias do Sul, RS SI 601 633 ±20 687-540 611 ±73 Schmitz 1988 RS-47.12 Sao Sebasta do Cai, RS SI 6061 635 ±45 653-571 612 ±41 Ribeiro and Ribeiro 1985 RS-PE-26a Esmeralda, RS SI 6561 635 ±45 653-571 612 ±41 Ribeiro and Ribeiro 1985 RS-PE-26a Esmeralda, RS SI 6563 650 ±56 660 ±-672 612 ±41 Ribeiro and Ribeiro 1985 RS-A-28 Curitiba, PR Beta 180906 680 ±70 684 ±576 630 ±54 Chryz et al 2003 RS-A-29 Vacaria, RS Beta 178090 710 ±60 735 ±564 635 ±56 Schmitz 1988 RS-A-29 Vacaria, RS Beta 178090 710 ±60 735 ±655 645 ±60 In Rogge 2005 RS-A-29 Vacaria, RS Beta 178090 710 ±60 775 ±656 645 ±60 In Rogge 2005 RS-A-29 Vacaria, RS Beta 178090 710 ±60	PR-UV-12	Cruz Machado, PR	SI 691	605 ± 120	673-528	601 ± 72	Chymz 1969
PH-UV-12 BitUrina, RS SI 691 622±120 687-540 611±45 Schmitz 1988 RS-37/127 Caxias do Sul, RS SI 205 630±205 791-434 611±46 Schimitz 1988 RS-FE-26a Esmeralda, RS SI 6561 635±45 653-571 612±41 Ribeiro and Ribeiro 1985 RS-FE-26a Esmeralda, RS SI 6563 650±55 661-572 617±44 Ribeiro and Ribeiro 1985 PR-CT-93 Curitiba, PR Beta 180907 680±70 684-576 630±54 Chryz et al 2003 RS-A-29 Vacaria, RS Beta 15342 680±80 575-694 635±59 Schnitz 1988 RS-A-29 Vacaria, RS Beta 150907 700±60 694-582 696±43 in Rogge 2005 RS-A-29 Vacaria, RS Beta 1738±96 772-594 733±95 Chryz 1988 PR-UB-4 Ubriata, PR SI 194 735±95 772-594 733±62 Smithsonian in Noelli 2000 PR-UB-4 Ubriata, PR SI 438 800±70 848-708 777±75 Chryz 1969	RS-68	Caxias do Sul, RS	SI 608	620 ± 90	662-554	608 ± 54	Schimtz 1988
HS-3/1/2/ Caxlas do Sul, HS S I 60/4 G 30 ± 7/0 Eb/-564 G 11 ± 40 Schmitz 1988 RS-C12 São Sebastiao do Cai, RS SI 205 630 ± 205 791-434 613 ± 178 Rogge 2005 RS-FE-28a Esmeralda, RS SI 6561 630 ± 205 761-434 Ribeiro and Ribeiro 1985 PR-CT-93 Curitiba, PR Beta 180906 660 ± 60 666-573 620 ± 46 Chryz et al. 2003 PR-CT-93 Curitiba, PR Beta 180907 680 ± 70 684-576 630 ± 54 Chrymz 1969 PR-CT-93 Curitiba, PR Beta 153842 680 ± 80 575-694 633 ± 55 Schmitz et al. 2002 RS-A-29 Vacaria, RS Beta 178090 710 ± 60 705-585 645 ± 60 in Rogge 2005 RS-A-14 São Sobastião do Caí, RS SI 1194 735 ± 95 772-694 733 ± 39 Chrwz 1981 PR-UB-4 Ubiratá, PR SI 298 810 ± 90 864-690 777 ± 87 Chrwz 1981 R3/127 Cavias de Sul, RS SI 606 840 ± 60 865-714	PR-UV-12	Bituruna, RS	SI 691	623 ± 120	687-540	614 ± 73	Schmitz 1988
HS-C-12 Sab Sepastia do do Lai, HS S I 205 630 ± 205 791-434 613 ± 178 PROGge 2005 RS-PE-28a Esmeraida, RS SI 6561 635 ± 45 653-571 612 ± 41 Ribeiro and Ribeiro 1985 PR-CT-33 Curitiba, PR Beta 180906 660 ± 60 666 ± 573 620 ± 46 Chmyz et al. 2003 PR-LV-11 Cruz Machado, PR SI 1010 680 ± 70 684 ± 576 633 ± 54 Chmyz et al. 2003 RS-A-29 Vacaria, RS Beta 153842 680 ± 60 655 ± 664 635 ± 59 Schmitz 1988 RS-A-29 Vacaria, RS Beta 178090 710 ± 60 705 ± 58 645 ± 60 in Rogge 2005 RS-A-29 Vacaria, RS Beta 178090 710 ± 60 705 ± 58 645 ± 60 in Rogge 2005 RS-C-14 Sia Sebastião do Cai, RS SI 1198 745 ± 65 772 ± 586 645 ± 60 in Rogge 2005 RS-C-14 Sia Sebastião do Cai, RS SI 243 800 ± 70 815 ± 69 772 ± 586 645 ± 60 in Rogge 2005 RS-C-12 Sia Sebastião do Cai	RS-37/127	Caxias do Sul, RS	SI 604	630 ± 70	657-564	611 ± 46	Schimtz 1988
HS-HE-26a Esmeralda, RS SI 6561 635±45 653-5/1 612±41 Ribeiro and Ribeiro 1985 PR-CT-93 Curitiba, PR Beta 180906 660±60 666±572 617±44 Ribeiro and Ribeiro 1985 PR-CT-93 Curitiba, PR Beta 180907 680±70 684±576 630±54 Chrymz et al. 2003 RS-A-29 Vacaria, RS Beta 153842 680±80 575-694 635±59 Schmitz et al. 2002 RS-A-29 Vacaria, RS Beta 17809 710±60 705-585 645±60 in Rogge 2005 RS-A-29 Vacaria, RS Beta 17809 710±60 705-585 645±60 in Rogge 2005 RS-C-14 Sab obsé dos Ausentes, RS S1 243 800±70 815-691 753±62 Smithsonian in Noelli 2000 PR-UV-12 Cruz Machado, PR S1 892 810±90 844-690 777±87 Chymz 1968 RS-37/127 Caxias de Sul, RS S1 698 830±60 848±70 877±17 Chymz 1969 PR-CT-33 Curitba, PR Beta 22644 844±70 877±17 </td <td>RS-C-12</td> <td>Sao Sebastiao do Cai, RS</td> <td>SI 205</td> <td>630 ± 205</td> <td>791-434</td> <td>$613 \pm 1/8$</td> <td>Rogge 2005</td>	RS-C-12	Sao Sebastiao do Cai, RS	SI 205	630 ± 205	791-434	$613 \pm 1/8$	Rogge 2005
HS-HE-2288 Estimation Estimation <thestimation< th=""> Estimation Estimati</thestimation<>	RS-PE-26a	Esmeralda, RS	SI 6561	635 ± 45	653-571	612 ± 41	Ribeiro and Ribeiro 1985
PR-U-133 Cultinuble, PR Beta 180900 600±601 600±70 684-576 630±54 Chrinz 4 al. 2003 PR-UV-12 Curitiba, PR Beta 180907 680±70 684-576 630±54 Chrinz 4 al. 2002 RS-A-29 Vacaria, RS Beta 153842 680±80 575-694 635±59 Schmitz et al. 2002 RS-A-29 Vacaria, RS Beta 153842 680±80 575-694 635±59 Schmitz et al. 2002 RS-A-29 Vacaria, RS Beta 178090 710±60 705-585 645±60 in Rogge 2005 RS-A-24 Vacaria, RS Beta 178090 710±60 705-585 645±60 in Rogge 2005 PR-UB-1 Uniao da Vitória, PR SI 2194 735±95 772-696 684±88 Chmyz 1981 Tapera, SC SI 243 800±70 816-690 777±87 Chymz 1969 PR-UV-12 Cruz Machado, PR SI 892 810±90 864-600 777±87 Chymz 1969 PR-CT-33 Campo Largo, PR Beta 22644 848±70 877-717 79±80 Chmyz et al. 2003 PR-CT-33 Curitiba, PR Beta 180904	RS-PE-28a	Esmeralda, RS	SI 6563	650 ± 55	661-572	617 ± 44	Ribeiro and Ribeiro 1985
PH-Ot-11 Chriz Machiado, PH S1 1010 600 ± 70 684-576 630 ± 54 Chrmyz et al 2003 RS-A-29 Vacaria, RS Beta 153842 680 ± 70 684-576 633 ± 54 Chrmyz et al 2003 RS-A-29 Vacaria, RS Beta 153842 680 ± 80 575-694 638 ± 56 Schmitz 1988 RS-A-29 Vacaria, RS Beta 178009 710 ± 60 705-585 645 ± 60 in Rogge 2005 RS-C-14 São Sebastião do Caí, RS S1 1198 745 ± 65 739-652 696 ± 43 in Rogge 2005 PR-UB-1 Uniao da Vitória, PR S1 1219 735 ± 95 772-694 733 ± 39 Chrmyz 1981 PR-UP-12 Cruz Machado, PR S1 892 810 ± 90 864-690 777 ± 87 Chrimz et al 2003 PR-UT-23 Carara Achado, PR S1 892 810 ± 90 866-712 795 ± 71 Chrmyz 1969 PR-CT-33 Campo Largo, PR Beta 2644 848 ± 70 877 ± 77 797 ± 80 Chrmyz 1978 PR-U53 Campo Largo, PR Beta 180904 850 ± 50 866-712 795 ± 71 Chrmyz 1978 PR-U540 S	PR-CI-93	Curiliba, PR	Bela 180906	660 ± 60	000-573	620 ± 46	
PR-C1-33 Clinitida, PR Beta 15/39/2 6/31/2 <t< td=""><td>PR-UV-II</td><td></td><td>SI 1010</td><td>680 ± 70</td><td>684-576</td><td>630 ± 54</td><td></td></t<>	PR-UV-II		SI 1010	680 ± 70	684-576	630 ± 54	
NS-A-29 Vacualia, RS Defail 103242 000 ± 00 S175-094 Colliniz ± 41.2002 RS-A-08 São José dos Ausentes, RS SI 2343 700 ± 60 694-582 633 ± 56 Schmitz 1988 RS-A-29 Vacaria, RS Beta 176090 710 ± 60 705-585 645 ± 60 in Rogge 2005 RS-C-14 São Sebastião do Caí, RS SI 1194 735 ± 95 772-596 644 ± 88 Chmyz 1981 PR-UB-1 Ubiratã, PR SI 12194 735 ± 95 772-694 733 ± 39 Chmyz 1968 Tapera, SC SI 243 800 ± 70 815-691 753 ± 62 Smithsonian in Noelli 2000 PR-UV-12 Cruz Machado, PR SI 892 810 ± 90 864-690 777 ± 77 Ristronian in Noelli 2000 PR-UT-33 Carinto A, RS SI 606 840 ± 60 865-714 799 ± 75 Schmitz 1943 PR-UB-4 Ubiritâ, PR Beta 180904 850 ± 50 866-723 795 ± 71 Chmyz 1978 PR-UB-4 Vacaria, RS Beta 144247 870 ± 50 884-738 811 ± 73	PR-CI-93	Curiliba, PR	Beta 150907	680 ± 70	684-576 EZE 604	630 ± 54	Chimyz et al 2003
N3-A00 Sature description Number of the second	RS-A-29	Vacalla, RS	Deta 100042	000 ± 00	070-094 604 590	633 ± 59	Schmitz 1099
NB-A-29 Valuatia, NS Defail 170300 /10±00 /10±00 /10±00 /10±00 (NB-NB) PR-UB-4 Ubiratã, PR SI 2194 735±95 772-596 684±48 Chmyz 1981 PR-UB-1 União da Vitória, PR SI 2194 735±95 772-596 684±88 Chmyz 1981 PR-UB-1 União da Vitória, PR SI 243 800±70 815-691 753±62 Smithsonian in Noelli 2000 PR-UV-12 Cruz Machado, PR SI 892 810±90 864-690 777±87 Chymz 1969 PS-77-75 Carisa de Sul, RS SI 606 840±70 877-717 797±80 Chmyz 1995 PR-CT-53 Campo Largo, PR Beta 22644 848±70 877-717 797±80 Chmyz 1995 PR-CT-33 Curitiba, PR Beta 180904 850±50 866-723 795±71 Chmyz 1978 RS-A-27 Vacaria, RS Beta 144244 870±60 884-738 811±73 Schmitz et al. 2002 RS-R-164b Snatt Caruz do Sul, RS SI 806 970±95 966-723		Sau Juse dus Auseriles, no	31 2343 Data 170000	700 ± 60	094-00Z	030 ± 30	in Degge 2005
N3-0-14 Side Sebastiatio Uo Cari, NS Si 1195 743±05 772-596 684±88 Chmyz 1981 PR-UB-1 Ubirati, PR Si 141 800±50 772-694 733±39 Chmyz 1968 PR-UB-1 União da Vitória, PR Si 141 800±50 772-694 733±39 Chmyz 1968 PR-UB-1 Cruz Machado, PR Si 892 810±90 864-690 777±87 Chymz 1969 RS-VZ-43 Tenente Portela, RS Si 598 830±60 848-708 778±70 Miller 1971 RS-37/127 Caxias de Sul, RS Si 606 840±60 866-714 790±75 Schmitz 1969 PR-CT-30 Curitiba, PR Beta 180904 850±50 866-723 75±71 Chmyz 1978 RS-A-27 Vacaria, RS Beta 144244 870±50 884-738 811±73 Schmitz et al. 2002 RS-A-27 Vacaria, RS Beta 144244 870±50 884-738 811±73 Schmitz et al. 2002 RS-A-27 Vacaria, RS Beta 144247 870±60 844-738 811±73 Schmitz et al. 2002 RS-A-27 Vacaria, RS Si 8106 91	NG-A-29	Vacalla, no	Deta 170090	710 ± 00	700-000	606 ± 42	in Rogge 2005
PR-UB-1 União da Vitória, PR Si 2194 7/3250 7/2-694 7/332 Gong 204 Si 203 Chunyz 1968 PR-UB-1 União da Vitória, PR Si 243 800±70 815-691 7/3±62 Smithsonian in Noelli 2000 PR-UV-12 Cruz Machado, PR Si 892 810±90 864-690 7/77±87 Chymz 1968 SS-VZ-43 Tenente Portela, RS Si 598 830±60 848-708 7/8±70 Miller 1971 RS-37/127 Caxias de Sul, RS Si 606 840±60 865-7714 790±75 Schmitz 1969 PR-CT-33 Curtiba, PR Beta 180904 850±50 866-723 795±71 Chruz 1975 PR-UB-4 Ubiritá, PR Si 2193 855±95 890-714 802±88 Chruz 1975 RS-A-27 Vacaria, RS Beta 144244 870±50 881-742 812±69 Schmitz et al. 2002 RS-A-27 Vacaria, RS Beta 144247 870±60 884-738 811±73 Schmitz et al. 2002 RS-A-27 Vacaria, RS Beta 142424 870±60 982-798 857±128 in Rogge 2005 RS-7212 <td< td=""><td></td><td>Libirată PP</td><td>SI 1190 SI 2104</td><td>743 ± 05 725 ± 05</td><td>739-032</td><td>690 ± 43</td><td>Chavy 1081</td></td<>		Libirată PP	SI 1190 SI 2104	743 ± 05 725 ± 05	739-032	690 ± 43	Chavy 1081
Theor Tapera, SC S1 441 500 150 753 ±62 Smithsonian in Noelli 2000 PR-UV-12 Cruz Machado, PR S1 892 810 ±90 864-690 777 ±87 Chymz 1969 RS-VZ-43 Tenente Portela, RS SI 598 830 ±60 848-708 778 ±70 Miller 1971 RS-VZ-43 Tenente Portela, RS SI 606 840 ±60 865-714 790 ±75 Schmitz 1969 PR-UT-53 Campo Largo, PR Beta 22644 848 ±70 877-717 797 ±80 Chrmyz 1969 PR-CT-53 Carnitob, PR Beta 180904 850 ±50 866-723 795 ±71 Chrmyz 1978 PR-UB-4 Ubirită, PR SI 2193 855 ±95 890-714 802 ±88 Chrmyz 1978 RS-A-27 Vacaria, RS Beta 144244 870 ±60 884-738 811 ±73 Schmitz et al. 2002 RS-A-27 Vacaria, RS Beta 180903 940 ±70 919-783 851 ±68 Chrmyz et al. 2003 RS-P-27 Born Jesus, RS SI 812 950 ±80 933-783 858 ±75 Beber 2004 RS-37/127 Caxias de Sul, RS Beta 153841 960	PR-UB-4	União da Vitória PR	SI 2194 SI 1/1	733 ± 93	772 694	004 ± 00 733 ± 30	Chmyz 1968
PR-UV-12 Cruz Machado, PR SI 892 810 ± 90 864-690 777 ± 87 Chymz 1969 RS-VZ-43 Tenente Portela, RS SI 598 830 ± 60 848-708 778 ± 70 Miller 1971 RS-37/127 Caxias de Sul, RS SI 606 840 ± 60 865-714 790 ± 75 Schmitz 1969 PR-CT-33 Campo Largo, PR Beta 22644 848 ± 70 877-717 797 ± 80 Chmyz 1995 PR-CT-93 Curtitba, PR Beta 180904 850 ± 50 866-723 795 ± 71 Chwyz 1978 PR-UB-4 Ubiritã, PR SI 2193 855 ± 95 890-714 802 ± 88 Chmyz 1978 RS-A-27 Vacaria, RS Beta 144244 870 ± 60 881-729 857 ± 128 in Rogge 2005 PR-CT-93 Curitiba, PR Beta 180903 940 ± 70 919-783 851 ± 68 Chmyz <i>et al.</i> 2002 RS-87-164b Santa Cruz do Sul, RS SI 812 950 ± 80 933-783 858 ± 75 Bebe 2004 RS-37/127 Caxias de Sul, RS SI 812 950 ± 60 926-804	111-00-1	Tapora SC	SI 242	800 ± 70	915 601	753 ± 62	Smithsonian in Noolli 2000
RS-V2-12 Ord Walchadd, H St 092 Ord 190 Ord 190 Ord 190 Ord 190 RS-V2-43 Tenente Portela, RS St 598 830 ±60 848-708 778 ±70 Miller 1971 RS-37/127 Caxias de Sul, RS St 606 840 ±60 865-714 790 ±75 Schmitz 1969 PR-CT-33 Curitiba, PR Beta 22644 848 ±70 877-717 797 ±80 Chmyz 1995 PR-0T-33 Curitiba, PR Beta 180904 850 ±50 866-723 795 ±71 Chmyz et al. 2003 PR-UB-4 Ubiritä, PR Beta 144244 870 ±50 881-742 812 ±69 Schmitz et al. 2002 RS-A-27 Vacaria, RS Beta 144247 870 ±60 884-738 811 ±73 Schmitz et al. 2002 RS-P-729 Curitiba, PR Beta 180903 940 ±70 919-783 851 ±68 Chmyz et al. 2003 RS-P-727 Born Jesus, RS St 812 950 ±80 933-783 858 ±75 Beber 2004 RS-4.27 Caxias de Sul, RS Beta 153841 960 ±60 926-804 865 ±61 in Rogge 2005 RS-U-2 S. Foo. De Paula, RS	PR-11/-12	Cruz Machado PR	SI 240	810 ± 90	864 690	733 ± 02 777 ± 87	Chymz 1969
Instruct 40 Instruct 40 Instruct 40 Instruct 40 Instruct 40 Instruct 40 RS-37/127 Caxias de Sul, RS Si 606 840±60 865±714 790±75 Schmitz 1969 PR-CT-53 Campo Largo, PR Beta 22644 848±70 877-717 797±80 Chmyz 1995 PR-UB-4 Ubiritã, PR Beta 180904 855±95 890-714 802±88 Chmyz et al. 2003 PR-UB-4 Ubiritã, PR Si 2193 855±95 890-714 802±88 Chmyz et al. 2002 RS-A-27 Vacaria, RS Beta 144244 870±60 884-738 811±73 Schmitz et al. 2002 RS-A-27 Vacaria, RS Beta 144247 870±60 884-738 811±73 Schmitz et al. 2002 RS-A-27 Vacaria, RS Beta 144247 870±60 884±738 811±73 Schmitz et al. 2002 RS-A-27 Vacaria, RS Beta 180903 940±70 919-783 851±68 Chmyz et al. 2003 RS-P-27 Bom Jesus, RS SI 812 950±80 933-783 858±75 Beber 2004 RS-37/127 Caxias de Sul, RS Beta 166588 <t< td=""><td>RS-V7-43</td><td>Tenente Portela RS</td><td>SI 598</td><td>830 ± 60</td><td>848_708</td><td>778 ± 70</td><td>Millor 1971</td></t<>	RS-V7-43	Tenente Portela RS	SI 598	830 ± 60	848_708	778 ± 70	Millor 1971
No. 67, 12.1 Gakab do Gui, 100 Stroke	RS-37/127	Cavias de Sul BS	SI 606	840 ± 60	865_714	790 ± 75	Schmitz 1969
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	PB-CT-53	Campo Largo PB	Beta 226//	$8/8 \pm 70$	877_717	797 ± 80	Chmvz 1995
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	PR-CT-93	Curitiba PR	Bota 18090/	850 ± 50	866_723	797 ± 00 795 ± 71	Chmyz $et al 2003$
RS-A-27Vacaria, RSBeta 144247870 \pm 00881-742812 \pm 00Schmitz et al. 2002RS-A-27Vacaria, RSBeta 144247870 \pm 00881-742812 \pm 00Schmitz et al. 2002RS-R-27Vacaria, RSBeta 144247870 \pm 00884-738811 \pm 73Schmitz et al. 2002RS-RP-164bSanta Cruz do Sul, RSSI 4066915 \pm 145985-729857 \pm 128in Rogge 2005PR-CT-93Curitiba, PRBeta 180903940 \pm 70919-783851 \pm 68Chmyz et al. 2003RS-9-27Bom Jesus, RSSI 812950 \pm 80933-783858 \pm 75Beber 2004RS-37/127Caxias de Sul, RSBeta 153841960 \pm 60926-804865 \pm 61in Rogge 2005RS-U-2S. Fco. De Paula, RSSI 808970 \pm 95966-792879 \pm 87Schimtz 1988RS-U-35Concórdia, SCSI 825975 \pm 90972-796884 \pm 88Beber 2004RS-AN-3Bom Jesus, RSBeta 1665881000 \pm 40951-843897 \pm 54Cope and Saldanha 2002RS-37/127Caxias do Sul, RSSI 6021140 \pm 401152-792972 \pm 180Schimtz 1988RS-37/127Caxias do Sul, RSSI 6011300 \pm 701282-11401211 \pm 71Schimtz 1988RS-37/127Caxias do Sul, RSSI 6051330 \pm 1001327-11281228 \pm 99Schimtz 1988RS-37/127Caxias do Sul, RSSI 6051330 \pm 1001327-11281228 \pm 99Schimtz 1988RS-328Sapiranga, RSSI 4	PR-UR-4	Libirită PR	SI 2193	855 ± 95	890-714	802 ± 88	Chmyz 1978
RS-A-27 Vacaria, RS Bota 144247 870±60 884-738 811±73 Schmitz et al. 2002 RS-A-27 Vacaria, RS Beta 144247 870±60 884-738 811±73 Schmitz et al. 2002 RS-R-P.164b Santa Cruz do Sul, RS SI 4066 915±145 985-729 857±128 in Rogge 2005 PR-CT-93 Curitiba, PR Beta 180903 940±70 919-783 851±68 Chmyz et al. 2003 RS-97/127 Caxias de Sul, RS SI 812 950±80 933-783 858±75 Beber 2004 RS-01-2 S. Fco. De Paula, RS SI 808 970±95 966-792 879±87 Schimtz 1988 RS-U-3 Concórdia, SC SI 825 975±90 972-796 884±88 Beber 2004 RS-AN-3 Bom Jesus, RS Beta 166588 1000±40 951-843 897±54 Cope and Saldanha 2002 RS-37/127 Caxias do Sul, RS SI 602 1140±180 1237-881 1059±178 Chmyz 1976 RS-37/127 Caxias do Sul, RS SI 601 1300±70 1282-1140 1211±71 Schmitz 1988 RS-37/127 Caxias do Sul, RS <td>RS-A-27</td> <td>Vacaria BS</td> <td>Beta 144244</td> <td>870 ± 50</td> <td>881_742</td> <td>812 ± 69</td> <td>Schmitz et al. 2002</td>	RS-A-27	Vacaria BS	Beta 144244	870 ± 50	881_742	812 ± 69	Schmitz et al. 2002
RS-RP-164b Santa Cruz do Sul, RS SI 4066 915±145 985-729 857±128 in Rogge 2005 PR-CT-93 Curitiba, PR Beta 180903 940±70 919–783 851±68 Chmyz et al. 2003 RS-P-27 Bom Jesus, RS SI 812 950±80 933–783 858±75 Beber 2004 RS-37/127 Caxias de Sul, RS Beta 153841 960±60 926–804 865±61 in Rogge 2005 RS-U-2 S. Fco. De Paula, RS SI 808 970±95 966–792 879±87 Schimtz 1988 RS-U-35 Concórdia, SC SI 825 975±90 972–796 884±88 Beber 2004 RS-AN-3 Bom Jesus, RS Beta 166588 1000±40 951–843 897±54 Cope and Saldanha 2002 RS-37/127 Caxias do Sul, RS SI 602 1140±40 1152–792 972±180 Schimtz 1988 RS-9F-01 Paso Fundo, RS SI 601 1300±70 1282–1140 1211±71 Schmitz 1988 RS-37/127 Caxias do Sul, RS SI 605 1330±100 1327–1128 1228±99 Schmitz 1969 RS-37/127 Caxias do Sul, RS	RS-A-27	Vacaria RS	Beta 144247	870 ± 60	884-738	811 ± 73	Schmitz et al. 2002
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	RS-RP-164b	Santa Cruz do Sul BS	SI 4066	915 ± 145	985-729	857 ± 128	in Bogge 2005
RS-P-27Both Jesus, RSSI 812 950 ± 80 $933 - 783$ 858 ± 75 Beber 2004RS-9.27Caxias de Sul, RSBeta 153841 960 ± 60 $926 - 804$ 865 ± 61 in Rogge 2005RS-U-2S. Fco. De Paula, RSSI 808 970 ± 95 $966 - 792$ 879 ± 87 Schimtz 1988RS-U-35Concórdia, SCSI 825 975 ± 90 $972 - 796$ 884 ± 88 Beber 2004RS-AN-3Bom Jesus, RSBeta 166588 1000 ± 40 $951 - 843$ 897 ± 54 Cope and Saldanha 2002RS-37/127Caxias do Sul, RSSI 602 1140 ± 40 $1152 - 792$ 972 ± 180 Schimtz 1988RS-S-61Taquara, RSSI 409 1190 ± 100 $1228 - 1009$ 1119 ± 109 in Rogge 2005RS-PF-01Passo Fundo, RSSI 601 1300 ± 70 $1228 - 1140$ 1211 ± 71 Schimtz 1988RS-37/127Caxias do Sul, RSSI 605 1330 ± 100 $1327 - 1128$ 1228 ± 99 Schimtz 1988RS-37/127Caxias do Sul, RSSI 605 1330 ± 100 $1327 - 1128$ 1228 ± 99 Schimtz 1988RS-37/127Caxias do Sul, RSSI 806 1385 ± 95 $1384 - 1202$ 1293 ± 91 Schimtz 1988RS-42S. Fco. de Paula, RSSI 603 1480 ± 70 $1477 - 1329$ 1403 ± 74 Schmitz 1969RS-37/127Caxias do Sul, RSSI 603 1480 ± 70 $1477 - 1329$ 1403 ± 74 Schmitz 1969RS-37/127Caxias do Sul, RSSI 603 1480 ± 70 $1477 - 1329$ <td>PB-CT-93</td> <td>Curitiba PR</td> <td>Beta 180903</td> <td>940 ± 70</td> <td>919-783</td> <td>851 ± 68</td> <td>Chmyz et al. 2003</td>	PB-CT-93	Curitiba PR	Beta 180903	940 ± 70	919-783	851 ± 68	Chmyz et al. 2003
RS-37/127Caxias de Sul, RSBeta 153841 960 ± 60 $926 - 804$ 865 ± 61 in Rogge 2005RS-U-2S. Fco. De Paula, RSSI 808 970 ± 95 $966 - 792$ 879 ± 87 Schimtz 1988RS-U-35Concórdia, SCSI 825 975 ± 90 $972 - 796$ 884 ± 88 Beber 2004RS-AN-3Bom Jesus, RSBeta 166588 1000 ± 40 $951 - 843$ 897 ± 54 Cope and Saldanha 2002RS-37/127Caxias do Sul, RSSI 602 1140 ± 40 $1152 - 792$ 972 ± 180 Schimtz 1988Tapera, SCSI 245 1140 ± 180 $1237 - 881$ 1059 ± 178 Chmyz 1976RS-S-61Taquara, RSSI 409 1190 ± 100 $1228 - 1009$ 1119 ± 109 in Rogge 2005RS-PF-01Passo Fundo, RSSI 601 1300 ± 70 $1282 - 1140$ 1211 ± 71 Schimtz 1988RS-37/127Caxias do Sul, RSSI 605 1330 ± 100 $1327 - 1128$ 1228 ± 99 Schimtz 1969RS-S-282Sapiranga, RSSI 414 1380 ± 110 $1394 - 1182$ 1288 ± 106 in Rogge 2005RS-A-2S. Fco. de Paula, RSSI 806 1385 ± 95 $1384 - 1202$ 1293 ± 91 Schimtz 1988PR-UV-17União da Vitória, PRSI 2197 1475 ± 65 $1465 - 1326$ 1396 ± 69 Chmyz 1969RS-37/127Caxias do Sul, RSSI 603 1480 ± 70 $1477 - 1329$ 1403 ± 74 Schmitz 1969RS-37/127Caxias do Sul, RSSI 603 1480 ± 70 $1477 - 1329$ $1403 \pm $	RS-P-27	Bom Jesus BS	SI 812	950 ± 80	933-783	858 ± 75	Beber 2004
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	RS-37/127	Caxias de Sul BS	Beta 153841	960 ± 60	926-804	865 ± 61	in Roage 2005
No 12StrictStric	RS-U-2	S Eco De Paula BS	SI 808	970 ± 95	966-792	879 ± 87	Schimtz 1988
RS-AN-3 Bom Jesus, RS Beta 166588 100 ±40 951-843 897 ±54 Cope and Saldanha 2002 RS-37/127 Caxias do Sul, RS SI 602 1140 ±40 1152-792 972 ±180 Schimtz 1988 Tapera, SC SI 245 1140 ±180 1237-881 1059 ±178 Chmyz 1976 RS-S-61 Taquara, RS SI 409 1190 ±100 1228-1009 1119 ±109 in Rogge 2005 RS-PF-01 Passo Fundo, RS SI 601 1300 ±70 1282-1140 1211 ±71 Schmitz 1988 RS-37/127 Caxias do Sul, RS SI 605 1330 ±100 1327-1128 1228 ±99 Schmitz 1969 RS-37/127 Caxias do Sul, RS SI 605 1330 ±100 1327-1128 1228 ±99 Schmitz 1969 RS-A-2 S. Fco. de Paula, RS SI 806 1385 ±95 1384-1202 1293 ±91 Schmitz 1988 PR-UV-17 União da Vitória, PR SI 2197 1475 ±65 1465-1326 1396 ±69 Chmyz 1969 RS-37/127 Caxias do Sul, RS SI 603 1480 ±70 1477-1329 1403 ±74 Schmitz 1969 RS-37/127 Caxias do Sul, RS	RS-U-35	Concórdia SC	SI 825	975 ± 90	972-796	884 ± 88	Beber 2004
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	RS-A-2	S. Fco. de Paula, RS	SI 805	1515 ± 105	1529–1338	1434 ± 95	Schmitz 1988

1966). The seeds could be eaten raw, roasted, or grounded into a paste. Pine nuts could be stored in tightly closed baskets soaked in water for a month and a half. Araucaria trees also provide an accessible and renewable wood supply. Because Araucaria nuts are also an important item in the diet of several faunal resources targeted by humans, including a variety of mammals, reptiles, and birds, its fruiting period should have coincided with an increase in the availability of game. The combination of Araucarianut collection and other wild plants, combined with the growing of tropical cultigens and hunting, would have been able to support rather sedentary populations in the highlands (Schmitz 2001/2002). To what extent did Taquara/Itararé groups manipulate or encourage the expansion of Araucaria forest is an important issue that requires further clarification through further archaeological and paleoecological research.

Landscape transformation related to agricultural practices

During the late Holocene there is a clear pattern in certain regions characterised by the increase of carbonised particles when Araucaria and the tropical forest began to expand and a decline in carbonised particles as climates became wet and less seasonal about 1410 and 900 cal. yr BP (1500 and 1000 ¹⁴C yr BP). As mentioned earlier, the SCG pollen record shows an abrupt increase in charcoal particles between 2980 and 1440 cal. yr BP (2850 and 1530 ¹⁴C yr BP) with a subsequent decline associated with the expansion of Araucaria forest beginning around 1440 cal. yr BP. A similar pattern was recorded in the southern highlands at Cambará do Sul, where the pollen diagram showed a sudden rise in charcoal abundance between c. 4320 and 1100 cal. yr BP (3950 and 1140 ¹⁴C yr BP), followed by a sharp decline.

Two aspects suggest that these fires were not natural and were predominantly set by humans. The first was that by the time the fires increase dramatically in SCG and CDS, the climate was wetter and less seasonal than previous periods; arguing against an increase in natural fires triggered by droughts. The second was the frequency and magnitude of these charcoal increases. The abrupt and frequent occurrence of charcoal particles at 4320 (CDS) and 2798 (SCG) cal. yr BP in systems that had not previously been fire prone is a strong indicator of human occupation (Bush *et al.* 2000; Bush *et al.* 2007). These data suggest the onset of slash-and-burn agriculture within the semideciduous forest that grew along the major tributaries up to 500–800 m elevation, and in the Atlantic tropical forest in the case of CDS.

These records provide support for the idea that well before Taquara/Itararé groups established a more permanent habitation of the highlands, pre-Hispanic groups were practicing slash-and-burn agriculture at lower areas beginning around 4320 cal. yr BP. Unfortunately, the archaeological record of that period is very incomplete and poorly understood. New data from surface sites in the lower Canoas River dating to *c*. 2540 cal. yr BP (2450¹⁴C yr BP) appear to indicate that the occupation of the lowland by Taquara/Itararé groups may have preceded the colonisation of the highlands (De Masi 2005). Further clarification of these patterns requires more archaeological and palynological research in lowland areas.

Both records show a decline in charcoal around 1000 yr BP but the continued presence of fine charcoal particles, which remained much higher than pre-4320 cal. yr. BP levels, suggests that fires were still frequent at a regional scale. This pattern suggests that Taquara/Itararé people continued to practice slash-and-burn agriculture at low sites, while *Araucaria* forest expanded and replaced grassland vegetation in the highlands.

The charcoal record also gives support to the idea that Taquara/Itararé groups practiced a mixed economy combining the collecting of *Araucaria* nuts in the highlands with the practice of slash-andburn agriculture at lower altitudes dominated by

Provenance			¹⁴ C age	64% range	Calendric	
Site	Locality	Lab no.	yr BP	cal BP	age cal. BP	References
RS-40	Caxias do Sul. RS	SI 607	1520+90	1517–1348	1433+84	Schmitz 1969
SC-IC-01	Icara, SC	Beta 72196	1580 + 60	1533-1412	1473 + 60	Schmitz 1995
RS-S-328	San Antonio. RS	SI 2345	1655 + 65	1655–1462	1559 + 96	Smithsonian in Noelli 2000
RS-S-239	San Antonio, RS	SI 2344	1740 + 65	1743–1582	1663 + 80	Smithsonian in Noelli 2000
RS-P-12	Bom Jesus, RS	SI 813	1810 + 85	1839–1633	1736 + 103	Schmitz and Brochado 1972
SC-CL	São Joaquim, SC	SI 811	1920 ± 50	1925–1816	1871 ± 54	Smithsonian in Noelli 2000
RS-AN-3	Bom Jesus, RS	Beta 166587	2180 ± 40	2290–2143	2217 ± 73	Cope and Saldanha 2002

semideciduous forest, which has been hypothesised by several authors (e.g., Beber 2005; Kern *et al.* 1989; De Masi 2005; Ribeiro 1999/2000; Schmitz 2001/ 2002). The abundance of plant processing tools recovered in low altitudes sites, including stone axes, mortars, and handstones, also provides indirect evidence for the importance of food-production in the subsistence economy of these groups.

At this point, one may ask what is the primary evidence for agriculture in the region. The study of the plant component of pre-Hispanic subsistence of the La Plata Basin is at a very early stage. Few projects have systematically applied archaeobotanical recovery techniques and, thus, there is a paucity of primary data to provide direct evidence of prehistoric plant use and economy. In addition to the recovery of carbonised Araucaria nuts in pithouse habitation surfaces, maize cobs and squash seeds were recovered associated with burials dated to c. 1740 cal. yr BP (1810¹⁴C yr BP) at the at the Abrigo do Matematico cave in the Bom Jesus locality, Rio Grande do Sul (Miller 1971). New evidence for the earlier presence of cultigens is beginning to accumulate. Maize (Zea mays) pollen was recorded at the São Francisco de Assis pollen sequence in the southern part of the plateau by c. 1960 cal. yr BP (1950⁻¹⁴C yr BP) (Behling et al. 2005).

The presence of these relatively early dates for domesticated plants in the SBHs should come as no surprise. Charcoal analysis from six shell mounds along the southern coast of the state of Rio de Janeiro, Brazil, dated between c 5500 BP and 1400 BP, documented for the first time the use of yams (Dioscorea sp.) in addition to palm and fruit trees in this region (Scheel-Ybert 2001). The study of dental wear patterns from 46 adult crania from the Preceramic Corondo site (Rio de Janeiro State), dated between 4740 and 3200 cal. yr BP (4200-3000 ¹⁴C yr BP), documented high caries rates, suggesting these Archaic populations had a high-consumption of starchy plants (Turner and Machado 1983). In the wetlands of south-eastern Uruguay, phytolith and starch grain analysis documented the presence of maize, squash, Phaseolus beans, and Canna and Calathea tubers starting shortly after c. 4740 cal. yr BP (4190 ¹⁴C yr BP) (Iriarte et al. 2004; Iriarte 2006b; Iriarte 2007).

The increasing role of domestic plants in the subsistence economies of the region since the mid-Holocene warrants renewed consideration in the light of growing palynological and microfossil botanical data. The application of appropriate techniques for botanical recovery in such acidic and clayey soils including phytolith, starch grains, and parenchyma (plant tissues) analyses in tandem with flotation, will allow us to answer major questions related to the role of domestic and wild plants in the economy of the Taquara/Itararé Tradition, as well as to examine the transition and specific mechanisms that led to the adoption of domesticates and the spread of agriculture in the region.

Conclusions

Recent archaeological and palaeoecological data in the SBHs allow us to carry out much more informed comparative analyses between regional-scale cultural sequences and their environments. The examination of pollen cores from the SBHs coupled with the archaeological record for the region indicates that the development of the Taquara/Itararé Tradition in strongly associated with the advance of Araucaria forest in the region during the late Holocene. The frequency of radiocarbon dates indicates a more intense human occupation of the SBHs after c. 1410 cal. yr BP, which peaks after around 900 cal. yr BP. The appearance of pithouse villages in addition to large and elaborate ceremonial centres is also a reflection of more permanent and territorial populations in the region.

The newly available resource, Araucaria seeds, appears to have played a major role in the subsistence economy of these groups allowing them to settle the highlands more permanently and at greater densities than before. Ecotonal areas where Araucaria forest, semideciduous forest, and grasslands converge may have been particularly attractive places in terms of abundance and diversity of resources. Mounting evidence also points to an increasing use of domesticated plants by these populations in addition to the collection of Araucaria nuts, other wild plants, hunting, and fishing. The charcoal records from SCG and CDS suggest that slash-and-burn agriculture at lower altitudes started c. 4320 cal. yr BP. Further clarification of these patterns requires more archaeological and palynological research in lowland areas.

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