Assessment of the discharge regime and water budget of Belo Vrelo (source of the Tolišnica River, central Serbia)

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Abstract. A sufficiently long spring discharge regime monitoring data set allows for a large number of analyses, to better understand the process of transformation of precipitation into a discharge hydrograph. It is also possible to determine dynamic groundwater volumes in a karst spring catchment area, the water budget equation parameters and the like. It should be noted that a sufficiently long data set is deemed to be a continuous spring discharge time series of more than 30 years. Such time series are rare in Serbia. They are generally much shorter (less than 15 years), and the respective catchment areas therefore fall into the “ungauged” category. In order to extend existing karst spring discharge time series, we developed a model whose outputs, apart from mean monthly spring discharges, include daily real evapotranspiration rates, catchment size and dynamic volume variation during the analytical period. So far the model has solely been used to assess the discharge regime and water budget of karst springs. The present paper aims to demonstrate that the model also yields good results in the case of springs that drain aquifers developed in marbles. Belo Vrelo (“White Spring”, source of the Tolišnica River), which drains marbles and marbleized limestones and dolomites of Čemerno Mountain, was selected for the present case study.

Key words: groundwater regime, catchment area, real evapotranspiration, dynamic volume, water budget, Belo Vrelo, Serbia.

Introduction

One the key prerequisites for efficient groundwater use for any purpose is knowledge of the hydrogeological characteristics of the area, the qualitative and quantitative characteristics of the groundwater, and the variations in these parameters over time. The aquifer regime is governed by a series of factors, pri-
marily the geological setting and the geomorphological, hydrogeological and climate conditions.

A catchment area is deemed to be gauged if the regime of relevant quantitative parameters has been monitored for at least 30 years. A catchment area is partial-gauged if monitoring lasted for 15 to 30 years, and ungauged if the monitoring period was shorter than 15 years (PROHASKA 2003). From this perspective, gauged catchment areas of karst springs in Serbia are extremely rare. There are only two such cases at present: a karst spring near the Village of Žagubica, which is the source of the Mlava River, and Sveta Petka Spring near the City of Paraćin (STEVANOVIĆ et al. 2014).

The time series of all the other karst springs are either much shorter (from one to ten years) or there has been no monitoring at all, the latter being more often the case. Assessments of the discharge regime and water budget of ungauged springs, or those that have not been studied in hydrological and hydrogeological terms, can be misleading. To prevent potentially erroneous assessments of the water budget equation parameters in such cases, or to at least ensure reasonable departures from real values, the Department of Hydrogeology of the Faculty of Mining and Geology at the University of Belgrade developed a model that extends relatively short (less than 15 years) time series of karst spring discharges. Apart from extending the length of existing time series, the model provides the catchment size, real evapotranspiration rates and variations in karst spring dynamic volume in the analytical period for which gaps in the existing time series of average monthly discharges have been filled. To date, the model has been tested and applied to about 20 karst springs in Serbia (RISTIĆ 2007; RISTIĆ VAKANJAC et al. 2010, 2013, 2014a, 2014b; STEVANOVIĆ et al. 2014). The difference between the catchment size computed by the model and the real catchment size of the karst spring resulting from detailed hydrogeological research is up to 10%.

Described below is the outcome of an application of the model, in this case to Belo Vrelo (source of the Tolišnica River), which drains marbles, marbleized limestones and dolomites of Čemerno Mountain.

**Geological and hydrogeological characteristics of the extended area of Belo Vrelo**

The karst spring of Belo Vrelo is situated in central Serbia, in Ivanjica Municipality (Fig. 1). The drainage area of the spring belongs to the catchment area of the
Tolišnica River, which in turn belongs to the wider Lopatnica River Basin on the slopes of Čemerno Mountain. The upper part of the Lopatnica River Basin features several springs, the largest being: Belo Vrelo (Fig. 2), Konjsko Vrelo (Horse’s Spring) and Mala Sokolina cluster of springs (Fig. 1). The altitude of most of the basin varies from 600 to 1000 m, while the edges of the basin in the south are as high as 1581 m a.s.l. (Fig. 3) (at Smrdljuš Summit of Čemerno Mountain).

The area is largely made up of Paleozoic deposits that hold a fractured aquifer. The sediments include phyllites, metamorphic quartz conglomerates, gneisses and schists, as well as marbleized limestones which are highly relevant to this research. In addition to Paleozoic sediments, there are also massive Middle Triassic dolomitic and marbleized limestones, but to a lesser extent. They occur as erosion remnants – peneplains, whose size is about 1.5 km². They constitute the margin of a large Triassic belt of Jelica Mountain, with which they are in contact. There are also Upper Cretaceous (Senonian) siltstones and schistose mudstones, overthrust on Senonian-Upper Cretaceous flysch (limestones, marls, sandstones and mudstones).

The faults (the most pronounced of which are found in the Rudno–Propljenica zone) are nearly parallel to the plane of overthrust, roughly running in the NNW–SSE direction. Flaking is also evident in the middle of this zone, where Triassic sediments are developed. Young transverse faults are quite common throughout the area (Brković et al. 1977).

Limestones, marbleized limestones and dolomites determine to a large extent the hydrogeology of the study area because of their fracture porosity resulting primarily from local tectonic movements. The aquifer stores a considerable amount of groundwater. Towards the surface, these rocks act as hydrogeological collector-conduits, while in the deeper reaches they serve as collector-reservoirs, discharged at the point of contact with semi-permeable and impermeable rocks via springs formed in places where local faults occur, like in the case of Belo Vrelo. The study of the hydrogeological characteristics of the terrain included an analysis of spring discharges, whose minimum-to-maximum ratio was less than 10 and the number of karst features less than one per km².

Recharge comes from precipitation and sinking of small surface streams. In the case of fracture porosity, groundwater pathways are determined by the geological formation, extent of fracturing and local hydrogeological conditions. At Belo Vrelo, groundwater circulates within faults, fractures and fissures. Groundwater drainage, or discharge, is gravity-driven and takes place via springs exposed on the ground surface, whose discharge rates vary. Belo Vrelo features the highest discharge rates; the lowest rate ever recorded was 40 l/s in December 1978, while the highest rate was more than 300 l/s. Konjsko Vrelo (Horse’s Spring) discharges some 5 l/s and Mala Sokolina springs 2 to 3 l/s. Belo Vrelo emerges on the ground surface below a bend called Tisovski Prevoj, on the northern slopes of Čemerno Mountain, at an altitude of 770 m. The spring is located at a distance of about 3 km from the Village of Tolišnica. The spring discharges through a steep slope at the point of contact between marbleized limestones and impermeable rocks. In the spring area, visible blocks of while marbleized limestones, 3–5 m
wide, suggest the existence of a fault that follows the gradient of the terrain (about 30°).

**Hydrological monitoring of Belo Vrelo**

In 1994, the National Hydrometeorological Service established hydrological stations at several karst springs, including Belo Vrelo. Hydrometric surveys and water level monitoring began on 1 January 1995 and continued through the end of 2002. Table 1 shows mean monthly and annual discharges of Belo Vrelo during the period of monitoring. Generally speaking, maximum discharge rates are usually attributable to snowmelt and spring rains.

Based on recorded daily discharges, the long-term average discharge for the period 1995–2002 was 0.127 m³/s. The maximum mean monthly discharge rate was 0.330 m³/s, registered in November 2002. The minimum mean monthly discharge was 0.070 m³/s, in October 1995. With regard to absolute daily discharge rates, the highest was 410 l/s on 24/25 December 2002 and the lowest only 67 l/s, recorded several times in 1995, 1996 and 2001. The 1995–2002 ratio of minimum-to-maximum discharges was 1:6, indicative of a relatively uniform discharge regime of Belo Vrelo. Figure 4 shows the 1996 hydrograph of this spring. The hydrograph includes one prolonged spring maximum (possibly two), and one minimum. The discharge peaks are generally attributable to snowmelt, which started in March/April, and spring rains (April/May/June). If snowmelt and spring rains occurred simultaneously, the hydrograph showed a prolonged peak. If the two events did not coincide, there were two or more lower peaks in the first half of the year. Conversely, the lowest discharge rates were noted in the summer months, when the discharge rates of Belo Vrelo were the lowest.

**Table 1. Mean monthly and annual discharges of Belo Vrelo (m³/s).**

<table>
<thead>
<tr>
<th>Year</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>0.124</td>
<td>0.135</td>
<td>0.140</td>
<td>0.150</td>
<td>0.150</td>
<td>0.147</td>
<td>0.111</td>
<td>0.086</td>
<td>0.081</td>
<td>0.070</td>
<td>0.080</td>
<td>0.079</td>
<td>0.113</td>
</tr>
<tr>
<td>1996</td>
<td>0.078</td>
<td>0.079</td>
<td>0.080</td>
<td>0.109</td>
<td>0.147</td>
<td>0.147</td>
<td>0.117</td>
<td>0.086</td>
<td>0.106</td>
<td>0.115</td>
<td>0.106</td>
<td>0.106</td>
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</tr>
<tr>
<td>1997</td>
<td>0.104</td>
<td>0.090</td>
<td>0.087</td>
<td>0.129</td>
<td>0.156</td>
<td>0.144</td>
<td>0.143</td>
<td>0.142</td>
<td>0.128</td>
<td>0.120</td>
<td>0.117</td>
<td>0.115</td>
<td>0.123</td>
</tr>
<tr>
<td>1998</td>
<td>0.115</td>
<td>0.131</td>
<td>0.115</td>
<td>0.127</td>
<td>0.115</td>
<td>0.108</td>
<td>0.103</td>
<td>0.086</td>
<td>0.087</td>
<td>0.100</td>
<td>0.105</td>
<td>0.100</td>
<td>0.114</td>
</tr>
<tr>
<td>1999</td>
<td>0.102</td>
<td>0.097</td>
<td>0.113</td>
<td>0.110</td>
<td>0.102</td>
<td>0.090</td>
<td>0.085</td>
<td>0.089</td>
<td>0.092</td>
<td>0.098</td>
<td>0.098</td>
<td>0.117</td>
<td>0.117</td>
</tr>
<tr>
<td>2000</td>
<td>0.123</td>
<td>0.114</td>
<td>0.125</td>
<td>0.109</td>
<td>0.098</td>
<td>0.088</td>
<td>0.081</td>
<td>0.079</td>
<td>0.093</td>
<td>0.089</td>
<td>0.089</td>
<td>0.088</td>
<td>0.098</td>
</tr>
<tr>
<td>2001</td>
<td>0.071</td>
<td>0.075</td>
<td>0.080</td>
<td>0.094</td>
<td>0.115</td>
<td>0.125</td>
<td>0.127</td>
<td>0.127</td>
<td>0.170</td>
<td>0.205</td>
<td>0.187</td>
<td>0.175</td>
<td>0.129</td>
</tr>
<tr>
<td>2002</td>
<td>0.247</td>
<td>0.241</td>
<td>0.232</td>
<td>0.264</td>
<td>0.188</td>
<td>0.178</td>
<td>0.172</td>
<td>0.208</td>
<td>0.253</td>
<td>0.266</td>
<td>0.330</td>
<td>0.214</td>
<td>0.232</td>
</tr>
</tbody>
</table>

**Qav** | 0.121 | 0.120 | 0.122 | 0.136 | 0.134 | 0.128 | 0.117 | 0.113 | 0.126 | 0.133 | 0.139 | 0.124 | 0.127 |

**σ** | 0.05 | 0.05 | 0.05 | 0.05 | 0.03 | 0.03 | 0.03 | 0.04 | 0.06 | 0.07 | 0.08 | 0.05 | 0.04 |

**Cv** | 0.45 | 0.45 | 0.41 | 0.40 | 0.24 | 0.25 | 0.26 | 0.40 | 0.47 | 0.51 | 0.60 | 0.37 | 0.35 |

**Cs** | 2.12 | 1.91 | 1.83 | 2.31 | 0.51 | 0.05 | 0.67 | 1.66 | 1.75 | 1.46 | 2.13 | 1.33 | 2.50 |

**Max** | 0.247 | 0.241 | 0.232 | 0.264 | 0.188 | 0.178 | 0.172 | 0.208 | 0.253 | 0.266 | 0.330 | 0.214 | 0.232 |

**Min** | 0.071 | 0.075 | 0.080 | 0.094 | 0.098 | 0.088 | 0.081 | 0.079 | 0.081 | 0.070 | 0.080 | 0.079 | 0.098 |

**Autocorrelation and cross-correlation analyses of Belo Vrelo**

Correlation analyses of the effect of annual precipitation totals on discharge rates of Belo Vrelo were undertaken to substantiate the above conclusion, or, in other words, to corroborate the correlation between precipitation and discharge. At a calendar year level, the coefficients of correlation were extremely low (r = 0.275 for the station at Ivanjica and r = 0.073 at Kraljevo). However, when the hydrological year was assessed, the coefficients of correlation were much higher, amounting to r = 0.465 at Ivanjica and as much as r = 0.667 at Kraljevo. This was a result of the fact that winter (November, December and January) precipitation remained in the catchment area and caused runoff/discharge during the next calendar year, after snowmelt. As a result, this type of analysis generally requires parameter averaging with regard to the hydrological year (1 October to 30 September). Then a cross-correlation analysis was undertaken to examine the effect of daily precipitation totals on discharge rates of Belo Vrelo. Figure 5 shows a cross-correlogram with a 100-day time lag. It is apparent that the strongest correlation...
between precipitation and discharge was noted after one day, but that there was a pronounced peak after 32 days, which was certainly due to snowmelt.

Apart from the cross-correlation analysis of Belo Vrelo, an autocorrelation analysis was undertaken for a time lag of 100 days (Fig. 6). The autocorrelogram showed a strong correlation even after 100 days, corroborating the earlier claim that the discharge regime of Belo Vrelo is relatively uniform (or that the memory is long, 100 days or more).

**Recession curve analysis**

Groundwater reserves of Belo Vrelo were assessed by recession curve analysis. A proper analysis of the retardation capacity of an aquifer requires a period of at least 90 days after heavy rainfall, with constant drainage and no recharge (aquifer recession). The discharge regime monitoring data revealed that these criteria were fulfilled in 1995, from 8 June to 2 November (a total of 148 days), and in 2000, from 23 March to 21 August (156 days). It should be noted that there was some rainfall during the period, but it had no significant effect on the spring discharge regime, as clearly shown in Figs. 7 and 8. Namely, during that period the rainfall was either torrential in nature, such that a part of the atmospheric precipitation was lost to surface runoff or evapotranspiration, or the precipitation totals did not cause any significant variation in the dynamic volume and thus had no effect on the discharge hydrograph.

Analysis of the regression stage of the hydrograph (Fig. 7) revealed two discharge microregimes, whose characteristics were nearly identical. Maillet’s equation (MAILLET 1905; Krešić & Bonacci 2009) was used to compute the drainage coefficient:

\[
\alpha = \frac{\log Q_f - \log Q_i}{0.4343 \cdot (t - t_0)}
\]

(1)

It follows from Eq. 1 that during the 1995 recession period (Fig. 7):
Similar results were obtained for the 2000 recession curve (Fig. 8):

\[
\alpha_1 = \frac{\log Q_{t_1} - \log Q_{t_0}}{0.4343 \cdot (t_1 - t_0)} = \frac{\log 0.155 - \log 0.081}{0.4343 \cdot 72} = 0.009013
\]

\[
\alpha_2 = \frac{\log Q_{t_2} - \log Q_{t_0}}{0.4343 \cdot (t_2 - t_0)} = \frac{\log 0.095 - \log 0.072}{0.4343 \cdot 156} = 0.001777
\]

The drainage coefficients were of the same order of magnitude and demonstrated average-to-good recession characteristics of the aquifer. These parameters were used to determine the summary volume of the discharged water. In the first case (1995), the summary volume was:

\[
V = V_1 + V_2 = \frac{Q_{t_1} - Q_{t_2}}{\alpha_1} \cdot 86400 + \frac{Q_{t_2} - 0}{\alpha_2} \cdot 86400 = 0.155 - 0.095 \cdot 86400 + 0.095 \cdot 0.009013 \cdot 86400 = 575141 + 4619100 \approx 5194241 \text{ m}^3
\]

and in the second case (2000):

\[
V = V_i = \frac{Q_{t_1} - 0}{\alpha_1} \cdot 86400 = \frac{0.12 - 0}{0.003193} \cdot 86400 = 3247490 \text{ m}^3
\]

Application of the model to fill gaps in average monthly discharge time series

A model developed at the University of Belgrade, Faculty of Mining and Geology, Department of Hydrogeology was used to identify the parameters of the water budget equation, primarily the catchment area of Belo Vrelo. The model comprises several levels; in the present case:

1. Generation of a long-term time series of Belo Vrelo discharges using a mathematical model of multiple nonlinear correlation (MNC) for spatial transfer of hydrometeorological data (PROHASKA et al. 1977, 1979, 1995). Here the MNC model was used to extend the time series of average monthly discharges of Belo Vrelo for the period 1960–2009. Figure 9 shows the intra-annual distribution of derived average monthly discharges of Belo Vrelo during the analytical period.

2. Determination of potential evapotranspiration (PET) by means of a modified Thornthwaite equation (RISTIĆ 2007; RISTIĆ VAKANJAC et al. 2013).

3. Determination of real evapotranspiration (RET), catchment size and water budget of the considered aquifer as follows: for rainy days PET = RET, and for days following rainfall RET was obtained from the exponential equation RET = PET Θ^2τ, where Θ is a dimensionless parameter and τ is the time step (1, 2, 3 ...). For the parameter values Θ = 0, 0.1, 0.2, ..., 0.8, 0.9 and 0.95, the water budget equation was established by calibrating the potential catchment size such that the condition \( V_0 \approx V_K \) was fulfilled. Then the function \( \Theta = f(F) \) was constructed, where the vertex represented the real catchment area (Fig. 10) (RISTIĆ VAKANJAC et al. 2013).

The resulting catchment size could be used to compute the parameters of the water budget equation (Table 2). Table 2 shows: the catchment size F (km²), the long-term average discharge Q (m³/s), the discharged volume of water W (10⁶ m³), the long-term average runoff modulus q (l/s/km²), the runoff layer h (mm), the average annual precipitation P (mm), the
average annual evapotranspiration E (mm), and the long-term average runoff coefficient $\varphi$. To clarify some of the parameters, following are the equations that were applied in the analysis.

- Discharged volume $W$ ($10^6$ m$^3$)
  \[ W = Q \cdot T \]  
  (2)

- Runoff layer $h$ (mm)
  \[ h = \frac{W}{F} \]  
  (3)

- Runoff modulus $q$ (l/s/km$^2$)
  \[ q = \frac{Q}{F} \]  
  (4)

- Average annual evapotranspiration $E$ (mm)
  \[ E = P - h \]  
  (5)

- Runoff coefficient $\varphi$
  \[ \varphi = \frac{h}{P} \]  
  (6)

where: $Q$ is the average annual discharge in m$^3$/s, $T$ is a one-year period in seconds, $W$ is the average annual discharge volume (m$^3$), $F$ is the catchment area in m$^2$, $P$ is the precipitation in mm, and $h$ is the runoff layer in mm.


<table>
<thead>
<tr>
<th>F</th>
<th>P</th>
<th>E</th>
<th>h</th>
<th>Qavg</th>
<th>q</th>
<th>W</th>
<th>$\varphi$</th>
</tr>
</thead>
<tbody>
<tr>
<td>km$^2$</td>
<td>mm</td>
<td></td>
<td></td>
<td>m$^3$/s</td>
<td>l/s/km$^2$</td>
<td>10$^6$ m$^3$</td>
<td>°</td>
</tr>
<tr>
<td>8.6</td>
<td>866.5</td>
<td>445.6</td>
<td>421.0</td>
<td>0.116</td>
<td>13.5</td>
<td>3.62</td>
<td>0.48</td>
</tr>
</tbody>
</table>

Assessment of the dynamic volume of Belo Vrelo

The basic water budget equation for a karst aquifer, with a monthly time step, is:

\[ \varphi = \frac{h}{P} \]  
(7)

where:

$P_{ij}$ - monthly precipitation totals of the karst catchment;

$h_{ij}$ - total monthly karst spring discharge layer;

$E_{ij}$ - monthly sums of actual (real) evapotranspiration in the karst catchment;

$V_{ij}$ - water volume of the considered karst aquifer in the j-th month; and

$\Delta_i$ - variation in stored karst groundwater, in the j-th month.

Given that monthly precipitation totals are known quantities and the average monthly runoff layer and monthly sums of real evapotranspiration were generated by the model, Eq. 7 is generally used to compute variations in dynamic volume during the analytical period. Such volume variations in a karst groundwater reservoir, derived in the above manner, are shown in Fig. 11. It is apparent that the total dynamic volume of Belo Vrelo, based on monthly values of all water budget components during the analytical period from 1960 to 2009, amounted to approximately $10^7$ m$^3$.

Conclusion

The general conclusion was that the annual average discharge rate of Belo Vrelo was $Q = 0.116$ m$^3$/s. Given that the catchment size of this spring is 8.6 km$^2$, the long-term average discharge layer during the analytical period was $h=421.0$ mm. With regard to water abundance, the specific yield of the Belo Vrelo drainage area was found to be 13.5 l/s/km$^2$, while the derived runoff coefficient suggested that 48% of all precipitation was infiltrated and then discharged via springs. The quality of this bacteriologically safe water is extremely high, such that it can be used for domestic water supply, agriculture and fish farming.

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References


Ristić Vakanjac V., Stevanović Z. & Čokorilo Ilić M. 2014. Underground piracy of Raska spring (southwestern Serbia) and concept for the delineation of catchment area and estimation of karst groundwater budget elements, Proceedings of the international conference and field seminar “Karst without Boundaries”, Trebinje, Bosnia and Herzegovina, pp. 207–212


Резиме

Процена режима истицања и биланса вода Белог врела (извор реке Толишнице, централна Србија)

Хидролошка изученост неког слива подразумева да су осматрања режима квантитативних параметара вршена у интервали од минималних 30 година. Карстна врела на жалост имају знатно краће низове осматрања (од 1 до 10 година) или, углавном, осматрања до сада уопште нису вршена на њима. Анализе режима истицања и прорачун параметара биланса код ових врела које можемо свrstati у групу хидролошких/хидрогеолошких неизучених сливова, могу понекад довести до прогресних закључака. Да би се потенцијалне грешке одређивања параметара биланса јединичне елиминисале код ових случајева, или свеле на разумне одступања од реалних вредности развијен је модел за потребе продужавања постојећег низова реалним оствареним и условима, могу понекад довести до прогресних закључака. Да би се потенцијалне грешке одређивања параметара биланса јединичне елиминисале код ових случајева, или свеле на разумне одступања од реалних вредности развијен је модел за потребе продужавања постојећег низова реалних остварених и условима, могу понекад довести до прогресних закључака.
јално припада општини Ивањице (слика 1) и дре- нира подручје Толишнице извршен је и применом методе анализе остатака — кречњачки — временским разрезом."}

Анализа резултата режим-

Прорачун резерви подземних вода извора реке Толишнице извршен је и применом методе анализе остатака — кречњачки — временским разрезом. Ова бактериолошки чи- ста вода и изузетног квалитета може се користити за потребе пољопривреде или пак за потребе водоснабдевања локалних домаћин- ства, за потребе водоснабдевања локалних домаћин- ства, за потребе водоснабдевања локалних домаћин- ства, за потребе водоснабдевања локалних домаћин- ства, за потребе водоснабдевања локалних домаћин- ства, за потребе водоснабдевања локалних домаћин- ства, за потребе водоснабдевања локалних домаћин- ства, за потребе водоснабдевања локалних домаћин- ства, за потребе водоснабдевања локалних домаћин- ства, за потребе водоснабдевања локалних домаћин- ства, за потребе водоснабдевања локалних домаћин- ства, за потребе водоснабдевања локалних домаћин- ства, за потребе водоснабдевања локалних домаћин- ства, за потребе водоснабдевања локалних домаћин- ства, за потребе водоснабдевања локалних домаћин- ства, за потребе водоснабдевања локалних домаћин- ства, за потребе водоснабдевања локалних домаћин- ства, за потребе водоснабдевања локалних домаћин- 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