ACTA FACULTATIS RERUM NATURALIUM UNIVERSITATIS COMENIANAE
Geographica Supplementum No 2/I, 1999, pp. 43-58

A NEW SURVEY OF SOURCES OF THE AMAZON

Bohumír Janský

Department of Physical Geography and Geoecology, Faculty of Sciences, Charles University, Prague, Czech Republic

Abstract: In the period since the 16th of June and the 1st of July 1999, the expedition Hatun Mayu (which means Big River in Quechua) was exploring the source area of the Apurímac River in the southern Peru. The expedition of seven members was lead by the author of this article from the Faculty of Science, Charles University, Prague, who, together with another organizer of the action, photographer Vladimír Šimek, had already visited this territory within the expedition Peru 95. The aim of the group was to measure the length of the formerly determined main source of the Apurímac River considered nowadays by a great part of world hydrologists as the longest source segment of the Amazon. Besides measuring the length of the course, the expedition members also measured flows and altitudes that enabled them to draw the lengthwise profile of the Río Carhuasanta stream.

Key words: Amazon river, Location of the source, Samuel Fritz, Natural conditions, Source area of Río Apurímac

1. HISTORICAL OUTLINE OF LOCALIZATION OF THE AMAZON SOURCES

1.1. Samuel Fritz - Bohemian Jesuit and author of a map of the Amazon

One of strong motivations of our expedition to the sources of the Amazon was above all the personality of a not much widely known Jesuit of Bohemian origin Samuel Fritz, famous mainly in the Hispanic world, as author of the first serious map of the Amazon.

After finishing his studies at the Faculty of Arts of Charles University and at the St. Wenceslas seminary, Fritz entered the Jesuit order. In 1683, he was sent together with J.

V. Richter and J. Burgr to a mission in the West Indies. Via Genoa, Seville, Cadiz and the Canary Islands, they first arrived to the island of Martinique and then to Cartagena in Columbia. After a distressful wandering upstream the Magdalena River, they progressively got, via Colombian towns of Popayán and Pasto to Quito in Equador, flew down the rivers of Pastaza and Napo down to the main course of the Amazon. Then they went upstream to the mouthing of the Huallaga River and to the seat of a Spanish mission in the settlement La Laguna.

Later Fritz progressively visited the tribes of Omanguas and Yurimanguas at the lower course of the Maranon River and the tribes of Ybanons and Aizuars at the mouthing of Rio Negro. During one of his expeditions in the region of the Amazon he was captured by Portuguese and 18 month imprisoned at the Portuguese Jesuit College in Pará at the mouthing of the Amazon. When he could finally go back to his Spanish mission in 1691, he mapped during his 1300 km long journey different affluents of the Amazon, islands, as well as Indian settlements. After visiting the Spanish viceroy in Lima, he stopped at the upper course of the Maranon River and described its sources in the mountain lake of Lauricocha. This place is up to now indicated as the source area of the largest river of the planet for instance by the New Encyclopaedia Britannica (1998).

Samuel Fritz was the first human who got acquainted during his travels with the whole main course of the Amazon from the sources of the Maranon to its mouthing. In 1707, he draw the second map of the river (the first one was done by Guillermo Sanson), which was much more perfect than the first one. The map (Map 1), incredibly precise given the time it has been done, was drawn with the help of protractor only.

1.2. Changing opinions on the sources of the Amazon

Up to the 1950's, the Maranon River was considered to be the source segment of the Amazon. Nearly 250 years after publication of the map of the Bohemian Jesuit Samuel Fritz in 1707, his localization of the Amazon source in the Lauricocha Lake in the Central Cordillera in the Peruvian Ands was still valid.

In the 1950's however, some data affirming that the second source stream of the Amazon, the Ucayali, was considerably longer than the Maranon River, were published. Contrary to the precedent period when the lengths of streams were established according to the map of scale 1:2 500 000 or 1:1 000 000, more detailed maps of scales 1:200 000 or 1:100 000 were then used. This enabled to consider all more important river meanders and the streams grew considerably longer.

In 1953, the French explorer Michel Perrin confirmed the supposition of the Peruvian colonel Gerardo Dianderas ensuring that the longest source stream of the Ucayali River is the Río Apurímac taking source at the foot of the Huagra Mountains in the Cordillera Chila in the southern Peru (department of Arequipa), to the north-west from the village of Cailloma. Geographers accepted this allegation for more than 15 years and long time it also appeared in the Czech textbooks of geography. This source was also mentioned by Rostislav Netopil in his publication "Hydrology of continents" (1972).

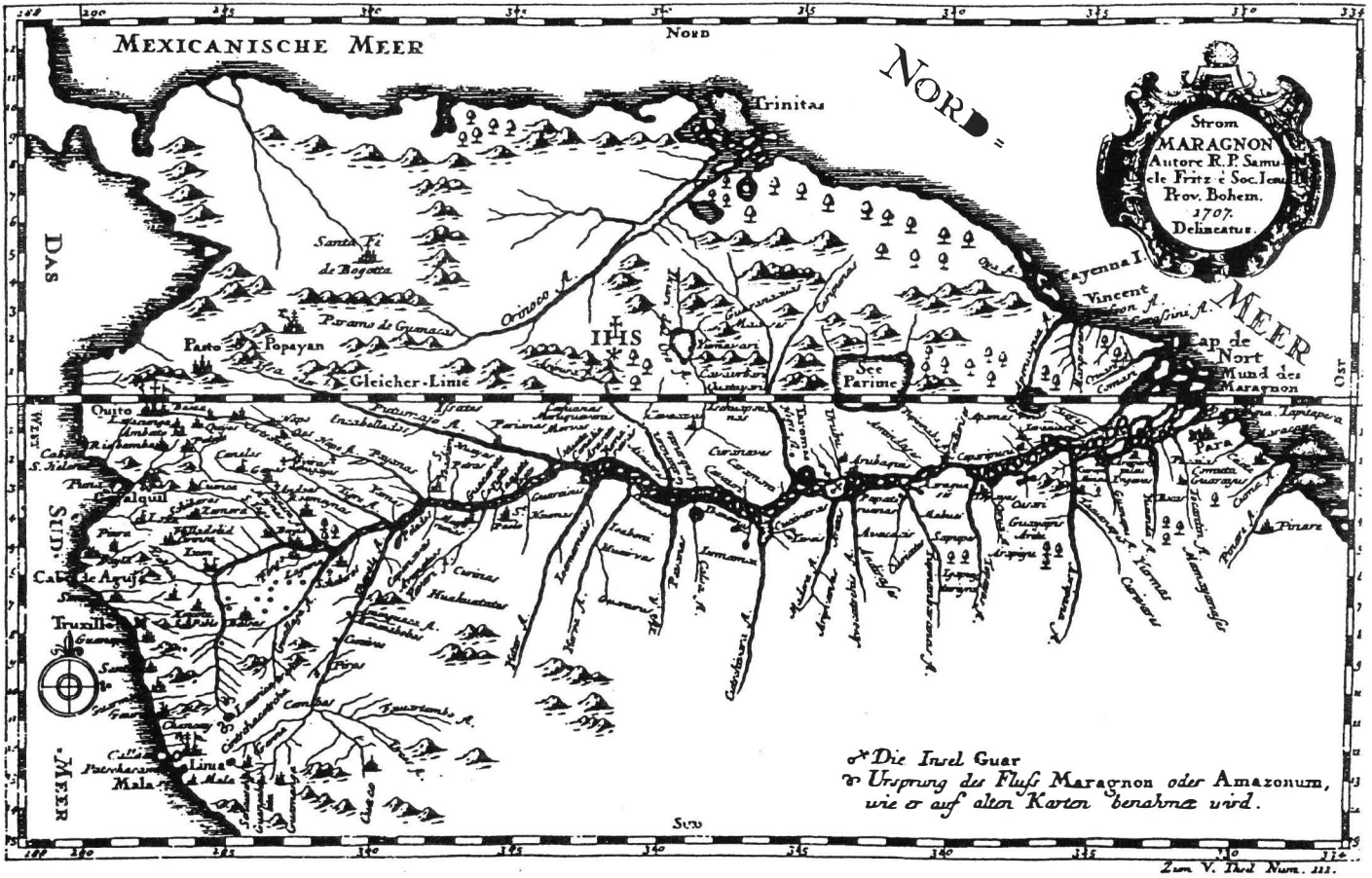

Fig. 1 The map of the Amazon s basin, work of Samuel Fritz from the year 1707

In 1968, Mr and Mrs Schreider designed as the source area of the Apurímac River the lake of Vilafro where Río Santiago takes source and which is situated about 11 km eastwards from the village of Cailloma.

A year later confirmed the English journalist Nicholas Asheshov who visited the region of the Cerro Minaspata summit (about 30 km south-westward from Cailloma) together with the parachutist and adventurer John Ridgway, that the source segment of Río Apurímac is situated exactly there.

In the same year, the eminent Peruvian geographer Carlos Penaherrera del Aguila published a monograph entitled "Geografía general del Perú". The published data were based on results of the research done by the Instituto Geográfico Nacional in Lima. As source of Río Apurímac is given Quebrada Carhuasanta at the northern foot of the Nevado Mismi Mountain and the source is precisely localized with the help of geographic co-ordinates - 71°40'36" of western longitude and 15°30'49" of southern latitude.

In 1971, an expedition was organized under the auspices of the National Geographic Magazine and the International Geodetical Service. It was led by the photographer Loren Mc Intyre who was accompanied by the mountaineer Richard Brandshaw and the geographer Víctor Tupa. The aim of the expedition was to confirm the hypothesis of American cartographers that Río Carhuasanta should be the longest source stream of the Amazon. Mc Intyre announced that the most remote source springs from a small lake at the foot of Nevado Choquecorao Mountain, generally called Nevado Mismi. This place is situated less than 2 km from the source found by Dr. Penaherra.

Further expeditions followed. In 1978 Walter Bonatti returned to the opinion of M. Perrin and designed as source segment of the Amazon Río Huarajo taking source at the foot of Cerro Huagra. When preparing a film about the Amazon, Jean Michel Cousteau visited in 1982 the region in question in the southern Peru and accepted the theory about localization of the sources presented 11 years before by McIntyre.

The last one of expeditions trying to find the source of the largest river of the planet took place in 1996. An international expedition led by the Polish adventurer Jacek Palkiewicz gathered two Russians (the glaciologist S. Ushnurtsev and the geographer R. Chayrutdinova from the Russian Academy of Sciences), four Peruvians (Z.N. Goicocheou from the Pontifica Universidad Católica del Perú, the hydrographers G. Faura and P. Rojas and the mountaineer J.L.T. Velasco) and the Italian adventurer T. Grego. The expedition determined a new source segment of the Apurímac River, and that Río Apacheta taking source at 5170 m at the foot of the Nevado Quehuisha Mountain in the Cordillera Chila range in the western Peruvian Ands. The authors consider this stream as the longest and the most watery source. It springs out at the highest altitude out of the all considered source segments of the Apurímac River.

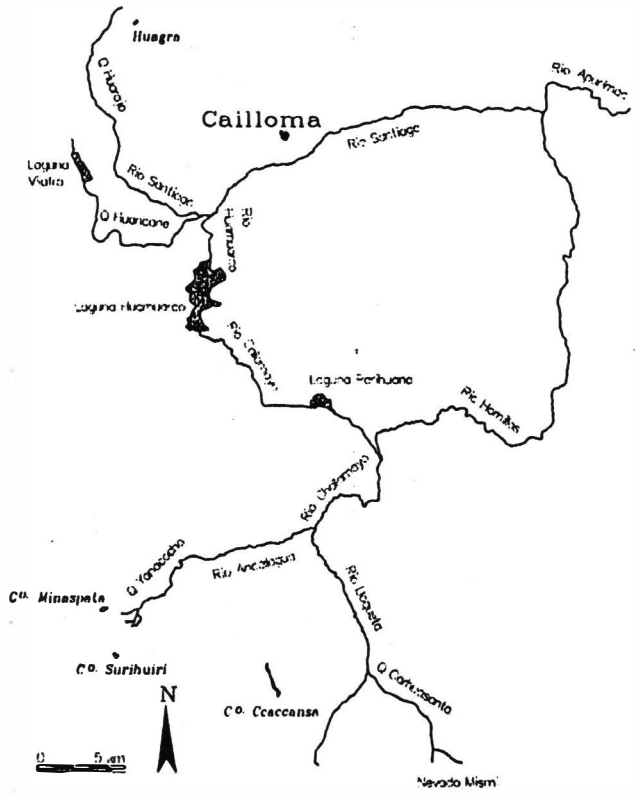

Fig. 2 Region of source of Rio Apurimac

Table 1 Survey of opinions on the localization of the Amazon sources

Author	Year	Source
S.J. Santos García	1935	Laguna Vilafro
Michel Perrin	1953	Cerro Huagra
col. Gerardo Diánderas	1953	Cerro Huagra - Rio Monigote
Heien a Frank Schreider	1968	Laguna Vilafro
Nicholas Asheshov	1969	Nevado Minaspata
Carlos Peñaherrera del Aguila	1969	Nevado Mismi - údoll Carhuasanta
Loren Mc Intyre	1971	Nevado Choquecorao
Walter Bonatti	1978	Río Huarajo
Jean Michel Cousteau	1982	Nevado Choquecorao
Jacek Palkiewicz, Zaniel I. Novoa Goicochea	1997	Nevado Quehuisha - údoll Apacheta

Source: Goicochea, Z.I.N. (1997), adapted

Table 2 Data about the length of the Amazon

Name	Country	Year	Length (km)
O. H. Walkey	Great Britain	1949	6517
E. J. Devroey	USA	1950	6595
C. Peñaherrera	Peru	1969	6762
J. Marcinek	G.D.R.	1978	6510
IIAP - Iquitos*	Peru	1980	6885
J. Cousteau	France	1984	7025
J.C.P. Grande	Brazil	1985	6571
IGN - Perú**	Peru	1989	6762
J. Marcinek, E. Rosenkranz	B.R.D.	1996	6516
P. Martini, J. Wagner	Brazil	1996	7062

*Instituto para la Investigacion de la Amazonia Peruana

**Instituto Geografico Nacional del Perú

2. PREPARATION OF THE EXPEDITION AND METHODS

The author of the article had prepared the expedition already since 1990 when he gave lectures on hydrology and general physical geography at two Peruvian universities - *Universidad Nacional Mayor de San Marcos* in Lima and *Universidad Nacional San Antonio Abad del Cuzco*. He obtained from the then Dean of the Faculty of Geography in Lima, Prof. Dr. Carlos Penaherrera, his monograph *Geografia general del Perú*, where the theory about the source area of the Amazon at the northern foot of the Nevado Mismi summit in the Quebrada Carhuasanta (Departemento Arequipa) was published for the first time. Although the author of the monograph had never visited this region, his hypotheses was based on the data found in maps of the National Geographical Institute in Lima.

Already at that time, the idea appeared to prepare field research of this region. Literature, maps and aerial photographs of the region in question were being progressively gathered. In 1995, the author of this article visited the Carhuasanta Valley within a geographical expedition of the Faculty of Science, Charles University, and proceeded to a preliminary survey of the region. Only in 1999, sufficient financial means and instruments of necessary quality for fieldwork were gathered.

Before the departure of the expedition, an analysis of hydrographical network of the upper part of the Río Apurímac source area was done on topographical maps 1:100 000 (sheets Cailloma 31-6 and Chivay 32-s). The length of all the streams that had been in past designed as sources of the Amazon was measured to the confluence of Río Santiago and Río Hornillos, situated at about 14.5 km eastwards from the village of Cailloma, where in the Río Apurímac begins. In the same time aerial photographs of a scale 1:50 000 were interpreted depicting the main ridge of the Cordillera de Chila Mountains and the upper course of Río Lloqueta with four principal sources.

Following instruments were used for field research:

- laser range finder LEM TM 30 (produced by Jenoptic, Germany) with tripod
- special height hauges ALTI PLUS 2 and BARIGO
- hydrometric propeller C 20 (produced by OTT Messtechnik, Kempten, Germany).

3. GEOGRAPHICAL LOCALIZATION AND NATURAL CONDITIONS OF THE REGION

The studied region is a part of mountain range Cordillera Occidental in the southern Peruvian Ands. The source area of the Apurímac River is situated at northern slopes of the main ridge of the Cordillera de Chila spreading between 15°04'20" and 15°32'19" of southern latitude and 71°36'38" and 71°54'00" of western longitude.

Administratively, the region belongs to the districts of Lari and Cailloma in the Cailloma province, which is a part of the department of Arequipa in the south of Peru. The mining village of Cailloma, starting point of the expedition, lies at about 140 km northwards from Arequipa. The distance is covered by bus on gravel roads in about 12 hours, while a good cross-country vehicle can manage it in eight hours.

3.1. Georelief

The studied region combines the relief of mountain ranges, river valleys, plateaux and a large intermontane basin. In the south, there raises the arc of the main ridge of the Cordillera de Chila Mountains with its highest summits (from the southeast to the northwest): Mismi (5597 m), Choquecorao, Hueracahua, Quehuisha, Calomorco, Ccaccansa, Jatunpila (5437 m), Surihuiri (5556 m) and Inaspata. The ridge in the same time forms the main continental water-shed between the drainage area of the Atlantic and the Pacific oceans, that is between the catchment area of the Apurímac River, affluent of the Amazon, and the Río Colca catchment area that as Río Camaná (at its middle course called Río Majes) mouths into the Pacific Ocean. The northern and the western slopes of the mountains are not as steep as their southern slopes where the canyon of Río Colca got deepened into unsolidified volcanic tuffs. The maximal height difference between the Río Lloqueta Valley in the north and the ridge line of the mountain range is 700 to 800 m, while the Río Colca Valley at the southern slope is incised into the depth of 2200 to 2500 m in comparison to the mountain ridge of the Mismi massif. After 30 km, the depth of the Colca canyon reaches 3200 m.

From the viewpoint of the geological stratigraphy of the relief, there are diverse dominant rock forms of both sedimentary and volcanic origin, dating from the Middle Tertiary to present. In the of Cordillera de Chila range, in the source area of Río Lloqueta and at the watershed with Río Ancollagua, rocks of Middle Tertiary appear at

the surface and form the stratigraphic unit *Tacaza*. In its upper part, which is up to 800 m thick, this formation consists of grey basaltic or ryolite lavas with frequent fissures filled by volcanic tuffs. In deep cuttings of rivers (for instance below the confluence of both source streams of Carhuasanta), there is often denuded a thick lacustrinal formation (up to 1000 m, in Goicochea, Z.I.N., 1997) with laminarly arranged greenish, locally violet coloured sands, with frequent fragment of volcanic rocks. While in the upper part of the formation lavas are pronouncedly predominant, tuffs and conglomerates with blocs of size from 0.5 to 10 m, are dominant in the depth. Pleistocene is represented by the 20 to 150 m thick *Barroso* formations, consisting of greyish andesites and porphyries under the form of lava nappes or vaults, but there are also typical stratovolcanos with remnants of original parasitic volcanic cones.

The major part of the catchment area of the Río Apurímac upper course is nevertheless formed by a large graded level and mainly by the very large Cailloma basin (*Depresión de Cailloma*). Pleistocene loams, sands and gravels, accumulated under the form of alluvia, glaciofluvial sediments and moraines fill it. Among the recent sediments, there are unsolidified sands, gravels and loams under the form of alluvial cones, fluvial alluvia, debris cones, including unsolidified material of stone and mud flows (*huaycos*).

Geomorphologic processes are also influenced by extreme climatic conditions enabling a huge accumulation of snow and occurrence of glaciers. Under these conditions, numerous lakes of glacial origin were formed (including laguna "Bohemia", see further) and locally there is also permafrost that in summer (December-March) periodically melts at its surface.

3.2. Climatic conditions

Climatic conditions are mainly influenced by high altitude oscillating between 4140 m a.s.l. at the confluence of Río Santiago and Río Hornillos (the place of origin of Río Apurímac) and 4319 m (place in the Cailloma village) up to the ridge of Cordillera de Chila with altitudes about 5500m. There is also a sensibly strong isolation from impacts of the Pacific Ocean and the Amazon Basin. During the three winter months (June - August) the mean monthly temperatures are inferior to 0°C, while during the night they even descend under -20°C. During the expedition, the lowest temperature registered at the bank of Río Challamayo was -18°C. In the warmest months (January, February), the month averages reach about 6 to 7°C. The nearest permanent climatic station in Yauri (3915 m a.s.l.), situated at about 50 km north-eastwards, registers a mean annual temperature of 3.5°C, the warmest month being January with an average temperature of 7°C, the coldest one then July (-0.6°C). The average local rainfall is 662.3 mm. Although in the studied region of the source area of Río Apurímac the temperatures are slightly lower, the total annual rainfall at higher altitudes reaches as much as 1000 mm. The major part of precipitation fall from November to March, while in January and February the whole studied region is covered by snow. The period May-September is characteristic by a low rainfall.

Similarly, as in the majority of partial mountains of Peruvian Ands, **glaciation** of the Cordillera de Chila massif is of local character. Because of a high altitude and a relatively great isolation from the ocean, there are favourable temperature conditions for formation of glaciers. The decisive part is there played by the quantity of fallen snow. Glaciers and long-term snow cover take an area of 33.89 km^2. The lower limit of long-term snow cover lies on northern slopes of the main ridge at about 5300 m a.s.l. The majority of the 87 glaciers fill cirques, from which descend short slope or valley glaciers. According to the inventory of glaciers in Peru, published in the *Atlas del Perú* (1989), the total volume of glacier mass in Cordillera de Chila is of 0.578 km^3, that is about 1.03% of the volume of all the glaciers in Peru.

Glaciers, long-term snow cover and permafrost create in the source area of the Apurímac River very favourable hydrological conditions for streams that they supply by water, especially in summer months (from November to March). Accumulation of melting water in source areas is backed by **vegetation** as well. Especially large green cushions called *champa (Distichia muscoides)* are able to absorb enormous quantity of water. They are firmly tangled stems, leaves and roots of different species of trailing plants forming sort of oval carpets. According to the water content or the presence of permafrost, their surface may be in some months hard or, on the contrary, very soft. Champa and other plant species form, by their successive growing and fading away of their lower parts, huge, up to 10 m thick, layers of humolites in the source area of Río Carhuasanta. Among the numerous vegetal species, let us mention especially grasses: *ichu (Stipa ichu), sora (Calamagrostis eminens), chilhuar (Festuca orthophylla), tisna (Stipa obtusa)*. An important nutrient for troops of Tylopodous (lamas, alpacas and vicunas) is the low shrub of *tola* (also called *llianta*, *Lepidophyllum rigidum*) that, once dried, is also used as combustible. A very dominant plant on mountain slopes at altitudes superior to 4500 m is *yarita* (also called *yareta, Azorella yareta*) often forming large, even several metres high cushions. For its high content of resins, it is, once dried, used as combustible.

4. HYDROGRAPHICAL AND HYDROLOGICAL CONDITIONS OF THE SOURCE AREA OF RÍO APURÍMAC

Even before the beginning of the expedition, hydrographical analysis of river network of the upper course of Río Apurímac and of all its sources was done with the help of topographical maps of National Geographical Institute in Lima (*Instituto Geographico Nacional*) and of aerial photographs of the upper course of Río Lloqueta. On the basis of these cartometrical works were established the lengths of all the sources designed in the past as source segments of the Amazon.

The results of measurements have explicitly confirmed the initial hypothesis that the sources of the longest source stream of the Apurímac River must be looked for at the foot of the massifs of Nevado Mismi and Nevado Quehuisha, where Río Lloqueta

originates by confluence of four source streams. Although in 1966 an international expedition headed by J. Palkiewicz designed as the main source the valley of Quebrada Apacheta, our measurements favoured the neighbouring valley of Quebrada Carhuasanta (see Tab. 3).

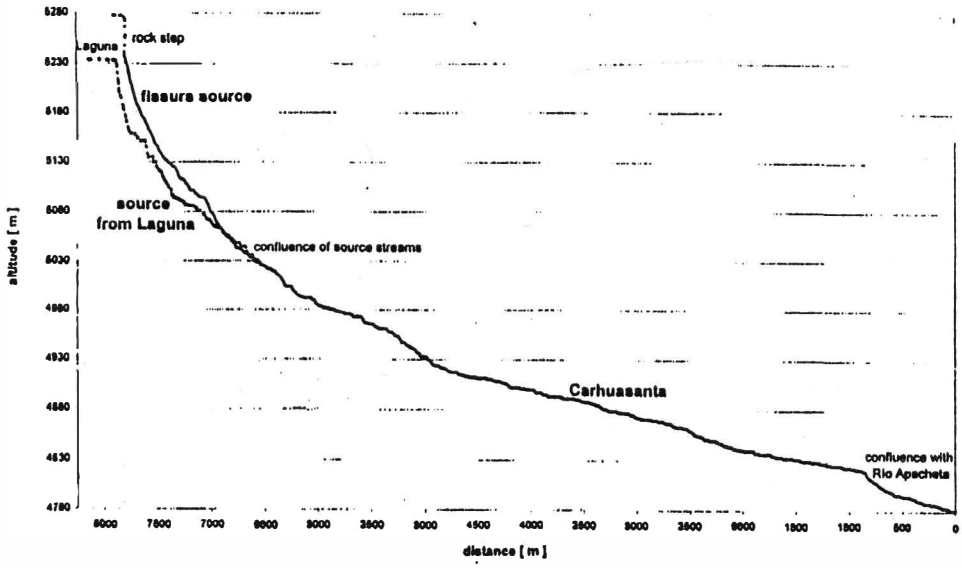

Fig. 3 Source segment of Rio Apurímac

Table 3 Results of our measurement of lengths of water streams in the source area of Rio Apurímac (measured on topographic maps of a scale 1 : 100 000, IGN, Lima Peru)

Source	Source stream	Length*(km)
Laguna Vilafro	Quebrada Huancane - R. Santiago	35,3
Cerro Huagra	Río Huarajo - R. Santiago	37,9
Cerro Minaspata	Quebrada Yanacocha - R. Ancollagua - R. Challamayo - R. Hornillos	55,5**
Nevado Mismi	Laguna "Bohemia" - Q. Carhuasanta - R. Lloquera - R. Challamayo - R. Hornillos	59**
Nevado Quehuisha	Q. Apacheta - R. Lloqueta - R. Challamayo - R. Hornillos	58,3**

* lengths measured from the source down to tha confluence of Río Santiago and Río Hornillos where Río Apurímac begins

** when measured via the artificial canal (that means via Lago Parihuana - Río Challamayo - Lago Huarjuarco - Río Huarhuarco - Río Santiago) all the lengths get 9.1 km longer

Besides measuring the lengths of natural riverbeds, a revision of river network has been done in the region of lakes of Laguna Parihuana and Laguna Huarhuarco where in the past an essential change of drainage situation occurred due to human intervention. We have this information thanks to one of the participants of Czechoslovak watercraft

expedition in 1982, ing. Bobák, and also from literature (for instance Asheshov 1970). It has been also confirmed during our visit in the locality. Sometimes after 1940, a mining engineer from Cailloma Mining Company let to dig a canal parting from the riverbed of Río Challamayo to feed the lake of Parihuana. The work went on at the outflow from the lake by digging a 2.7 km long underground tunnel. Later on, a small dam and an aqueduct were built to bring water into two water power plants supplying by power copper and silver mines. According to our measurements, this intervention prolonged the source segment of Río Apurímac of 9.1 km compared with the natural riverbed via Río Hornillos.

Studying results of the international expedition of 1996 confirmed us that it is highly necessary to carry out detailed earth measuring with the help of the latest instruments. For measuring lengths, we chose the latest version of laser range finder LEM TM 30 produced by Jenoptik and enabling a millimetre precision. We thus entirely excluded using GPS that cannon reach the requested precision. In that connection it is possible to entirely doubt the results of the above-mentioned expeditions using this instrument for measuring lengths.

Fig. 4 Source area of Rio Carhuasanta at the foot of Nevado Mismi

Fig. 5 The left source of Rio Carhuasanta rises from the Laguna at the altitude 5233 m. In the backyard is Nevado Mismi.

4.1. Results of field survey in the Carhuasanta Valley

Measuring works started in the basic camp of the expedition at the confluence of both principal sources of Río Lloqueta, that is Carhuasanta and Apacheta, at the altitude of 4781 m. When measuring, we proceeded along the main river bed in a way to record all the meanders. To the confluence of both principal sources of Carhuasanta (5026 m a.s.l.) the stream measured 6521.1 m with a descent of 245 m and the mean inclination of 3.76%.

The **left source of Carhuasanta** parts from a glacier lake indicated on maps as Laguna with its surface at the altitude of 5233 m. Geographical co-ordinates of this sources are the following: 15°30'33" of southern latitude and 71°41'34" of western longitude. On the day of measuring (June 23), the minimal outflow of the lake was 9 l/s. This water went down over a rock step at 5228 m a.s.l. and under the form of fine spray fell down on a firn field at 5212 m. The upper edge of this small waterfall was distant only 15.5 m from the outflow from the lake. The total length of Carhuasanta from the left source makes then 7872.9 m. The left source has, just to the confluence with the right source, a descent of 186 m with a mean inclination of 13.76%.

The **right source of Carhuasanta** rises by a huge fissure spring under a 36 m high vertical rock wall at 5238 m (the upper edge of the step is at an altitude of 5274 m). Geographical co-ordinates of this source are the following: 15°30'7" of southern latitude

and 71°41'13" of western longitude. The abundance of the spring the day of measurement (June 24) was 20 l/s. The rock wall is penetrated by a vertical fault zone interfering deep against the slope. It is certain that the source is fed by melting snow and by the glacier at the foot of Mismi above the rock step and that the water penetrates into largely open fissures. The total length of Carhuasanta from its right source is 7799.3 m. It has, just to the confluence with the left source, a descent of 212 m with a mean inclination of 16.59%.

During the field works, *flow* was measured at three streams. In Río Lloqueta, it reached 535.9 l/s on June 21 at 13 o'clock above the confluence with Río Ancollagua (altitude 4721 m, width of riverbed 6.2 m, water temperature 3°C). The flow of Río Apacheta was 205.9 l/s above the confluence with Río Carhuasanta (altitude 4788 m, width of riverbed 2.2 m, water temperature 1°C). The flow of Río Carhuasanta was 168.6 l/s above the confluence with Río Apacheta (altitude 4799 m, width of riverbed 2.75 m, water temperature 1°C). The second and the third measurements were done under stable conditions at 9, respectively 9.30 o'clock on June 24 with the help of hydrometric propeller C 20 produced by OTT.

5. CONCLUSION

When determining the main sources of a stream, hydrographic practice takes into consideration the following criteria: length of course together with altitude of the source, stretch of water area, flow, levelling of lengthwise profile and evolution age of river bed. With view to these criteria, we can state the following:

- Río Carhuasanta is the main source of Río Apurímac and by that also of the Amazon. This statement is backed by the results of our field and cartometric measurements. The total length of the source segment from the left source of Carhuasanta in the glacier lake of Laguna down to the beginning of the Apurímac River (confluence of Río Santiago and Río Hornillos) is 59,573 km.
- The sources of Río Carhuasanta are situated at the highest altitude of all the sources described by previous expeditions, and that at 5238 m (the right source) and at 5233 m (the left source).
- The largest catchment area of all the sources of Río Lloqueta is registered by Carhuasanta (19.6 km², for comparison Sillanque 14.1 km², Apacheta 14.1 km², Ccaccansa 8.8 km²), see also the data given by Goicochea, Z.I.N. (1997).
- Río Apacheta is only favoured by a greater flow (205.9 l/s while Río Carhuasanta 168.6 l/s).
- The artificial canal going from Río Challamayo and feeding the lakes of Parihuana and Huarhuarco elongates the source segment of Río Apurímac of 9.1 km. The natural riverbed is nevertheless Río Hornillos.

- The longest source segment of the Amazon has the following course: sources of Río Carhuasanta - R. Lloqueta - R. Challamayo - R. Hornillos - at its confluence with R. Santiago begins Río Apurímac. At its lower course, this one changes its name to R. Ene and then to R. Tambo. At its confluence with R. Urubamba begins Ucayali and after its confluence with Maranon the Amazon.

In spite of precious results reached by the expedition, we consider our work as a further stage in studying the source area of the largest water stream on the Earth. We are convinced that the same methods we have used in the case of Carhuasanta must be used for measuring other considered source stream, mainly Río Apacheta and Río Ccaccansa. Only then, the discussion about the source of the Amazon can be closed.

References

Asheshov, N. (1970): The real source of the Amazon is a glacier on a remote mountain called Minaspata. Peruvian Times, October 30.

Atlas del Perú (1989): Inventario de Glaciares del Perú. Hidrándina S.A. Unidad de Glaciología e Hidrología. Huaráz, Peru.

Cardich, A. (1959): Leyenda y verdad sobre el origen del Río Amazonas. Universidad de Buenos Aires, Argentina.

Goicochea, Z. I. Novoa (1997): El origen del Río Amazonas. Pontificia Universidad Catolica del Peru. Lima, Peru.

Edym (1992): Descubrimiento del Río de las Amazonas. De la Colección Vida Amazonas. Estudios, Ediciones y Medios (EDYM). Madrid, Spain.

Faura Gaig, G. (1964): Los Ríos de la Amazonía Peruana. Imp. del Colegio Militar Leoncio Prado. Lima, Peru.

Hidrandina, S.A. (Inventario de Glaciares del Perú. Unidad de Glaciología e Hidrología, CONCYTEC. Huaraz, Peru.

Janský, B. (1997): Samuel Fritz - Bohemian Jesuit and author of a map of the Amazon. Acta Universitatis Carolinae - Geographica. Roč. XXXII, No. 2, p. 149 - 154.

Janský, B. (1991): Las ocho regiones naturales del Perú. Acta Universitatis Carolinae - Geographica. XXVI, No. 1, p. 17 - 35.

Marcinek, J. (1978): Das Wasser des Festlandes. Justus Perthes Verlag, 3. Aufl. Gotha, D.D.R.

Marcinek, J. - Rosenkranz, E. (1996): Das Wasser der Erde. Justus Perthes Verlag. Gotha, B.R.D.

Martini, P. - Wagner, J. (1996): Depicting the headwater of the Amazon River - Trough the use of remote sensing data. Brazilian National Institute of Space Research - INPE. S o Paulo, Brasil.

McIntyre, L. (1972): The Amazon - Mightiest of Rivers. National Geographic Magazine. Washington, USA.

Palkiewicz, J. (1997): Towards the origin - In search of the Amazon, the most extraordinary river on Earth. El Dorado. Lima, Peru.

Peñaherrera del Aguila, C. (1969): Geografía General del Perú. Editorial Auzonia. Lima, Peru.

Pulgar Vidal, J. (1987): Geografía del Perú. Las ocho regiones naturales. PEISA. Lima, Peru.

Raimondi, A. (1965): El Perú. Universidad National de Ingenería. Editores Técnicos Asociados. Lima, Peru.

The New Encyklopaedia Britannica (1998): Macropaedia. Nr. 27, p. 706. The University of Chicago, USA.

Resume

Nové vyměření pramenu Amazonky

Ve druhé polovině června 1999 se uskutečnila expedice Hatun Mayu (kečuánsky "Velká řeka"), která směřovala do pramenné oblasti řeky Apurímac na jihu Peru. Sedmičlennou výpravu vedl autor článku, který společně s dalším organizátorem akce, fotografem a kameramanem Vladimírem Šimkem, navštívil toto území již při expedici Peru 95. Ještě před cestou bylo provedeno měření délek toků jednotlivých zdrojnic řeky Apurímac na leteckých snímcích a topografických mapách v měřítku 1 : 100 000. U předem vytypované hlavní zdrojnice Río Carhuasanta byla pak v terénu detailně změřena její délka a stanoveny nadmořské výšky, které umožnily vynesení podélného profilu toku. Rovněž se uskutečnilo měření průtoků vody na hlavních pramenných tocích Rio Apurímac.

Jedním z motivů expedice byla postava jezuity českého původu Samuela Fritze, který se především v hispánském světě proslavil jako autor první kvalitní mapy Amazonky. Fritz, narozený v Trutnově, postupně absolvoval Filosofickou fakultu Karlovy Univerzity, Svatováclavský seminář v Praze a poté vstoupil do jezuitského řádu. V roce 1683 byl spolu s J.V. Richterem a J. Burgrem vyslán do misijní služby v tehdejší Západní Indii. Po dlouhé cestě přes italský Janov, španělskou Sevillu, Cádiz, Kanárské ostrovy, ostrov Martinique, kolumbijský přístav Cartagenu a strastiplném putování proti proudu řeky Magdalena, andská města Popayán, Pasto a Quito, splutí řek Pastaza a Napo se dostali až na hlavní tok Amazonky. Proti jejímu proudu se vydali k ústí Huallagy do sídla španělské misie La Laguna. V dalších letech Fritz postupně navštívil několik indiánských kmenů na dolním Mara onu a při ústí Rio Negro. Po zajetí Portugalci byl 18 měsíců vězněn v portugalské jezuitské koleji Pará při ústí Amazonky. Po propuštění v roce 1691 mapoval během 1300 km dlouhé plavby přítoky Amazonky, říční ostrovy i jednotlivé indiánské osady. V roce 1693 navštívil španělského místokrále v Limě a na zpáteční cestě popsal prameny Amazonky v horském jezeře Lauricocha. Jako pramennou oblast největšího veletoku na Zemi udává tento region dodnes New Encyclopaedia Britannica (1998). Fritzova mapa Amazonky z r. 1707 byla v pořadí druhá na světě (po Guillermo Sansonovi), avšak mnohem dokonalejší.

Do 50. let 20. stol. byl za pramenný úsek Amazonky považován Maranon, tzn. více než 250 let platila teorie S. Fritze. Za pomoci map větších měřítek bylo zjištěno, že druhá zdrojnice Amazonky - Ucayali je výrazně delší než Maranon, a tak mnohé expedice zamířili poté do pramenné oblasti Río Apurímac, nejdelší zdrojnice Ucayali. Od roku 1953, kdy byl za pramen největší řeky světa označen vrchol Cerro Huagra v pohoří Cordillera Chila na jihu Peruánských And, se uskutečnilo několik výprav, které se snažily přesně určit místo pramene (viz. tab. 1). V souvislosti s tím se také objevovaly v literatuře odlišné údaje o délce Amazonky (viz. tab. 2).

Po revizi údajů všech dosavadních výprav a detailních kartometrických měřeních na topografických mapách a leteckých snímcích se autor článku vrátil k původní teorii

Prof. Dr. Carlose Pe aherrery z roku 1969. Cílem expedice bylo tedy potvrdit na základě výsledků terénních měření, že nejdelší zdrojnicí řeky Apurímac a tedy Amazonky je Quebrada Carhuasanta v departamentu Arequipa na jihu Peru.

Součástí tohoto článku je stanovení přesné geografické lokalizace pramenů a popis přírodních podmínek regionu hlavního hřebene a severního úpatí pohoří Cordillera Chila, který je součástí pásma Cordillera Occidental jižních Peruánských And. Pozornost je přitom věnována charakteristikám georeliéfu, rozsahu zalednění, klimatickým a vegetačním poměrům.

Detailní analýze jsou podrobeny hydrografické poměry pramenné oblasti řeky Río Apurímac. V článku jsou uvedeny výsledky měření délek všech dosud uvažovaných pramenných úseků na topografických mapách (viz. tab. 3), dále údaje o antropogenní transformaci říční sítě, která byla v minulosti uskutečněna v souvislosti s těžbou rud vzácných a barevných kovů.

Podstatnou částí textu jsou výsledky terénního průzkumu, který proběhl v údolí řek Río Lloqueta a Río Carhuasanta. Vzhledem ke kritériím, které se v hydrografii používají pro určení hlavního toku bylo stanoveno:

- Río Carhuasanta je hlavním pramenem řeky Río Apurímac a tudíž i Amazonky. Celková délka pramenného úseku od levé zdrojnice Carhuasanty v ledovcovém jezeře Laguna až po vznik řeky Apurímac (soutok Río Santiago a Río Hornillos) činí 59,573 km.
- Prameny Río Carhuasanta leží v nejvyšší nadmořské výšce ze všech zdrojnic, které byly popisovány předchozími expedicemi, tzn. 5238 m (pravá zdrojnice), resp. 5233 m (levá zdrojnice).
- Ze všech zdrojnic Río Lloqueta má Carhuasanta největší plochu povodí (19,6 km^2).
- Ve prospěch Río Apacheta hovoří pouze větší průtok vody (205,9 l/s) oproti Río Carhuasanta (168,6 l/s).
- Umělý kanál, který se odděluje od Río Callamayo a napájí jezera Parihuana a Huarhuarco, prodlužuje pramenný tok Río Apurímac o 9,1 km. Přírodním řečištěm je však Río Hornillos.

Nejdelší pramenný úsek Amazonky má následující průběh: prameny R. Carhuasanta - R. Lloqueta - R. Callamayo - R. Hornillos - jeho soutokem s R. Santiago vzniká R. Apurímac. Ten mění na středním a dolním toku název na R. Ene a R. Tambo. Jeho soutokem s R. Urubamba vzniká R. Ucayali a po soutoku s R. Maranon vzniká Río Amazonas.