Spore-pollen analysis of samples from the surface soil in the vicinity of lakes, at the end of Heihe River and their environmental indications

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Abstract: Spore-pollen analysis of fourteen samples at the surface soil in the vicinity of lakes, at the end of Heihe river had been analyzed and modern field vegetation had been investigated. The contents of native-born, territorial, upland vegetation in the spore-pollen at the surface soil had been calculated. The effects of wind and flowing water on the kinds of spore-pollen and environmental indications of the sediment environment, spore-pollen origin, spore-pollen combination had been estimated. Once the principle of spore-pollen at the surface soil have been known, the evolutional process of vegetation and climate which were reflected by the spore-pollen from the score section of Juyanhai lake have been recovered.

Key Words: lower Heihe River, surface soil pollen, environmental implication

Lakes at the end of Heihe River lie in the area where the Asia summer winds marches with the westerly winds, which are very sensitive to the environmental changes and whose spore-pollen combinations record the environment reflection of the middle area of Europe and Asia to the global changes. However, lakes in the west droughty area have their specialty, most of them are semi-open lakes [1] that supplied by rivers emanate from high-altitude mountains. Their spore-pollen combinations implicate far more complicated environment indications than those close lakes. In droughty areas, gale and temporality onrush are very normal natural phenomena, these phenomena can transport external pollen far to the deposit area and mix with native pollen, which makes it more difficult to explain the environmental implication of the spore-pollen record about the semi-open lakes in droughty area [2]. So, research on the pollen environmental implication of the surface oil in the vicinity of this kind of lake can provide a reasonable and correct explain for the regeneration of the ancient environment using the deposit spore-pollen record of the semi-open lakes in droughty area.

1. The river basin area survey

The Heihe River basin lies in the north of the middle area of Qilian Mountain, it emanates from the Qilian Mountain, passes on Qinghai, Gansu, Neimenggu province, and ends at the Juyan lake in the west of Ejina Qi. The Heihe River is 821 km long and its basin area is 130,000 km^2. Its upper part is from the riverhead to the Hawk-down valley, that from Hawk-down valley to Justice Valley is its middle part and from Justice Valley to the end is its lower part. At its upper part, the north side of Qilian Mountain is high altitude, cold, and waterish. It is cold temperate zone and semi-droughty climate. Its precipitation is 250-750 mm and modern glacier develops above 4000m. There are forest and boscage at the middle and sub-mountain; it is the path-flow forming area [3]. Its droughty temperate zone at the plain of the middle and lower part, dry and little rain, precipitation is less than 100mm. There isn't agriculture because of the shortage of irrigation and it is path-flow using area and dissipating area. The plants in this area show great territorial. It is snow zone, high mountain cushiony plant zone, high

mountain meadow zone, high mountain boscage zone, conifer (broadleaf) forest zone (include Qinghai spruce, mountain poplar, Qilian cypress etc.), grassland hungriness zone, hungriness zone etc. from the high altitude area to the low altitude area [4-5]. The lower Heihe River lies in the south-east of the middle Asia hungriness. It is Guaizi lake north mountain, which connects Alashan altiplano Zongnai Mountain and Yabulai Mountain, and its east is Gobi area. Badanjilin desert lies in its south-east; In its west and south, there is denudation low mountain, knap, Gobi, which is connected with the Mazong Mountain and the north part of the North Mountain. It is low mountain, knap and Gobi in the north-west and north. The middle part is composed of rush plain and plain oasis of the Ejina River at the lower Heihe River. These low mountains and knaps tend from east to west and most are covered by naked rock or gravel. It's higher at the south-west side and lower at the north side and takes on topography that low and plain at the middle side. The altitude of this area is about 1200-1400m; the relative height is 50-150m; the plain zone's altitude is about 1000m, the lowest is 900m and the altitude of the wash of west Juyan lake is the lowest: 820m [6]. This area is surrounded by mountains around three sides. The warm-wet air current from the Pacific Ocean and the Indian Ocean can hardly reach here because of the obstruction of high mountains, altiplano and long distance. This area is controlled by high-pressure air current in the latter half of the year and west wind in the first half of the year. It's mainland climate, has sparsely vegetation, dry, low precipitation, high vaporization, cold in winter, hot in summer, acute air temperature change in a year and in a day, plenty sunlight, much sand blown by wind. The mean year temperature is 8.3℃, -12.5℃ at January and 26. 3℃ at July. The uttermost high temperature is 41.6℃ and the extreme low temperature is -36.1℃. The mean precipitation is 38.2mm, evaporation is 3653.0mm. The wind is mostly west wind and north-west wind [7].

There are two deltas at the lower Heihe River: one is the Gashunnuoer, Suoguonuoer delta at the lower Jindong River and West River, the other is the ancient delta lies to the west bank of the ancient Juyanze Lake, which is the north-west edge part of the Badanjilin desert now. The Heihe River separates two branches when it reaches the north side of the Wolf-heart Mountain at Qingshantou Ejina Qi, the west branch flows to Gashunnuoer, the east separates two branches again when it flows 60-70km from the Wolf-heart Mountain, one branch, Jindong River (Nalin River), flows to Suoguonuoer, another branch flows to ancient Juyanze, passing by the ancient delta at the ancient Juyan City and Black City, but this branch is billabong now [8]. The area of Juyanze once was 2600km^2. It was 726km^2 at the Qing and Hang dynasty still. The Heihe River water system moved to west and was cut at the upper part at the 1 century A.D. The water flew into the lake decrease acutely and the ancient Juyan lake shrunk into the West Lake and the East Lake. The West Juyan lake is Suoguonuoer and the West is Gashunnuoer now [9].

The basin of Ejina River, which was generally termed "Juyan" or "Weak water & Quicksand" at ancient time. It ranges 300km, sand everywhere and very droughty there. As the natural block of the Badanjilin desert and North Mountain, which locates at the east and west side of the Ejina River respectively, the two sides of Ejina River become important west route way of our country. Its lower part and the vicinity of Juyan lake reach the desert and shield the west river. Huanghe River and the Sky Mountain is near the east and west side of this region. There is plenty of water and grass here and it is very suit for stockbreeding and agriculture. At Hang dynasty, the center government often had furious battle with the leader of Hun. It is recorded that massive military establishment been built here and the army resident here at Emperor Wu's time of West Hang dynasty. These martial actions last about two centuries. There are still some fort relics at Juyan [10]. At East Hang dynasty, 1560 tenements, about 4733 people, lived here [11]. At Hang dynasty, people primarily developed the lower part of the two deltas, and when time went to Xixia and Yuan dynasty, the lower part of the two deltas began sandy, the develop emphases changed to the middle part. At that time, there was still water at the dry riverbed lied to the south of the Black City, it flew from south-west to north-east and ended at the ancient Juyanze lied to the north-east of the Black City. Later, the lower Ejina River way shifted to west, and the ancient Juyanze shrunk to a little lake, the Swan Lake, for the lack of riverhead. It is plain sandlot at the Black City, but it once was oasis when the Ejina River passed by here. Some minorities lived here. They migrated when the river way shifted. This area was abandoned and the soil sanded absolutely. The city became ruin, and place nearby became Gobi. The

quicksand accumulated almost as high as the top of the rampart at the north-east corner [12]. A legend said that the abandon of the Black City was because of war. Somebody said that it's because Gen. Feng Sheng conquered Yinaiji Road at the 5th year of Hongwu. However, the < History of Ming Dynasty > recorded that this city surrendered at that time, so massacre couldn't happen and the residence couldn't be demobilized. The year of the latest unearthed documentary is the 1st Xuanguang year at North-yuan dynasty. A copperplate founded at the 1st Tianyuan year was unearthed later. These discoveries suggested that there were still residence at Yijinai City at North-yuan dynasty. At the telophase of Yuan dynasty and the initial stage of Ming dynasty, Gen. Kuokuotiemuer was stationed at Gansu and the Yijinai City should be one of his bases. It is speculated that the abandon of the Black City happened after Gen. Kuokuotiemuer was defeated. At that time, the whole country was in chaos, the new Ming dynasty had no enough power to control this area. The Yinaiji City lost its important political and military status, people scattered, trench abandoned, river cut, the herd had to find new place to live, and only left an abandon city [12]. So, we suggested that the ancient river way be abandoned at the telophase of Yuan dynasty and the initial stage of Ming dynasty. And from then on, the oasis became desert slowly.

The Juyan lake is mainly supplied by the Heihe River. The riverhead of Heihe River is naturally influenced greatly. The year mean yunoff was about one billon m^3 at the lower Heihe River at 1950's. Later, irrigation agriculture was developed in large-scale, with the greatly increased water demand for agriculture, the figure decreased sharply to 750 million m^3 when it came to 1960's. Lakes shrunk slowly or even to dry. The west Juyan lake dried up at the autumn in 1961. The east once was dry in 1973, 1980, 1986 and dried completely at 1994. The disappearing of Juyan lake brought great influence to the economy and the environment of Ejina. When the west and east Juyan lake is dry, desert soil expands rapidly, the dunes in the vicinity of the Ejina River activated inch by inch, rich meadow and Juyan oasis become desert gradually. The line of groundwater descends continuously and the quality worsens for the lack of the supply of surface water [9].

2. Methods

Present can provide us a key to research the past. This principle provides a science foundation geographical research, so to botany research. We research various ancient life-forms only by determining the nature of life-forms nowadays and studying their environment. We have to carry through the research to ancient environment in the guide of acquaintanceship now. Before analyzing the spore-pollen of Juyan lake, we researched the modern plants of Heihe river basin and analyzed spore-pollen of surface samples in the vicinity of Juyan lake to find out the ratios of native, regional and mountain vegetation in the surface soil pollen and the influence of wind and glide to the content of spore-pollen. Only if we understand these rules, can we replay evolvement course of the plant and climate imaged by the spore-pollen from the section of Juyan lake.

Table 1 records the sampling locations of surface samples in the vicinity of lower Heihe River. Samples are decalcified by HCl, and then wipe off dissociative humus acid and other gelatine substance, then desilicified by HF, then floated with a solution confected by HI, KI, Zn. Vegetation is sparse at Gobi and desert, some samples contain little spore-pollen. However, it can up to 150 or even to 308 particles at the oasis. The spores of Leguminosae may root in herbage or woody, it's hard to divide them, so we consider them herbage spore [13].

Table 1. The sampling location of spore-pollen of surface samples near Juyan lake

No.	Sampling location	Longitude(east)	Latitude(north)
1	North to east ancient Juyanze	101°52'10″	41°52'03″
2	Dust-color soil at the south to the center of Gashunnuoer Lake before the lake is lost	100°55'31″	42°26'29″
3	Beside the first bridge of the east Heihe River	101°04'34″	41°57'37″
4	Beside the second bridge of the east Heihe River	101°07'27″	41°58'59″
5	Beside the 7th bridge of the east Heihe River	101°11'22″	41°59'25″
6	West to the Hang dynasty war flame ruin of marquis Zhenbei(diluvium)	101°14'02″	42°09'04″

7	30m north to the Shen tree	101°05'48″	42°10'58″
8	North to the county, south to the Shen tree (in the riverway)	101°05'58″	41°48'22″
9	Remaining agrarian soil of Xixia or Yuan dynasty at the north of Black City	101°08'38″	41°45'29″
10	Underwater deposit at the north of the Swan Lake	101°34'38″	42°00'34″
11	Underwater deposit of the Suoguonuoer	101°16'20″	42°19'50″
12	River-bed deposit of the East river near the county	101°07'00″	42°13'31″
13	As same as No. 9		
14	As same as No. 4		

3. Analyzing results of spore-pollen from surface soil samples

We identify 29 generics, including about 20 familiar generics. To sum up, the spore-pollen combinations are monotone. The main combination components are shrubby and herbage plants spores, it accounts for 90%, several even to 96%, of the total number of spore-pollen (table 2.), main are *Chenopodiaceae, Artemisia, Tamaricaceae, Leguminosae, Ephedra* and some *Gramineae, Compositae, Polygonum, Corylus, Cyperaceae, Aster* and *Caryophyllaceae* etc. Arid plants (for the research area is droughty, arid plants mentioned in this article include some extremely xerophil) mainly are *Nitraria, Elaeagnus,* its highest content can reach 3.9%. Woody plant can reach 9%, mainly are conifers, including *Pinus, Picea, Abies, Sabina* etc. Broadleaf plants mainly are *Betula, Salix* and *Populus* etc. The content of ferm is 0.4-1.7%, mainly are *Selaginella*, sometimes *Lycopodium* and *Filicales*.

4. Environmental implication of the combination of spore-pollen samples from surface soil

The percentages of shrub and herbage plants of most samples are above 90% in spore-pollen combinations of surface soil samples, it reflects the vegetation environment of the desert. Little samples contain few spore-pollen and hard to count their percentages and this reflects the vegetation sight of the desert. It's the same in essence with the vegetation of oasis, desert and Gobi now.

The main nature arbor are *Populus davidiana Sehrenk* and *Elaeagnus angustifolia L.* Man-made forest mainly is *alamo*, *Salix daliensis C.F. Feng et S.T. Chao, Ulmus pumila L, Prunus armeniaca L, Prunus persica Batsch, pear, Malus asiatica Nakai, Malus pumila Mill, Vitis vinifera L* etc. Nature shrubby mainly are *Tamari ramosissima Ledeb, Haloxylon ammodendron Bunge, Atraphaxis bracteata*, *Salsola arbusculiformis Drob, Calligonum mongolicum Turcz, Clematis songarica Bunge, Gymnocarpos przewalskii Maxim, Lycium ruhenicum Murr, Lonicera microphylla Roem et Schult, Rosa xanthina*, *Ammopiptanthus mongolicus Cheng f, Caragana opulens Kom, Nitraria sibirica Pall, Zygophyllum xanthoxylum Maxim, Linum stelleroides Planch, Tourn ex L, Eriobotrya japonica Lindl* etc. Herbage plants mainly are *Medicago falcate L, Ayropyron cristatum Gaertn, reed, Agriophyllum squarrosum Moq, Reaumuria soongorica Maxim, Ajania pallasiana Poljak, sand Allium L, base Allium L, Karelinia caspia Less.Karelinia caspia Less.*, *Gynmocarpos przewalskii Maxim, Desert wormwood, Kalidium foliatum Moq, Glycyrrhiza uralensis Fisch, Sophora alopecuroides L, Avena fatual* etc [(14)]. There are only xeric plant and super-xeric plant at the lithoid gray-umber desert soil and sandy gray-umber desert soil (most are gravel mountain) in the low mountain and monadnock desert vegetation area, mainly are *Ephedra przewalskii Stapf, Desert wormwood* accompanying *Gobi Stipa L, Ajania pallasiana Poljak, Multi-roof Allium L, Anabasis brevifolia C.A.Mey* etc. On the gray-umber desert soil and parget gray-umber desert soil (gravel Gobi altiplano) of the altiplano desert vegetation area, there mainly are *Reaumuria soongorica Maxim, Haloxylon ammodendron Bunge, Tourn ex L, Calligonum mongolicum Turcz, Desert wormwood, Tamarix, toothed leaf Nitraria sibirica Pall* etc, accompanying with *Alhagi pseudalhagi Desv, Zygophyllum xanthoxylum Maxim, Phyllostachys propinque McClure* etc. On the salty meadow, damp meadow, salty soil and sandy soil of the lowland meadow vegetation area, the mainly vegetation communities are *Populus davidiana Sehrenk, Elaeagnus angustifolia L, Tamarix, reed, Sophora alopecuroides L and Achnatherum splendens Nevsk* etc, accompanying

with *Nitraria sibirica Pall, Lycium rathenicum Murr* and weed [15]. The fieldwork shows the main plant community at Gashunnuoer, Suoguonuoer, ancient Juyanze and the desert around are *Haloxylon ammodendron Bunge, Suaeda glauca Bunge and Nitraria sibirica Pall* etc; and *Tamarix ramosissima Ledeb, Tourn ex L, Sophora alopecuroides L, Salsola collina Pall* etc. at the immovable and semi-immovable dune area (include the north-west edge of the Badanjilin desert); in the oasis around the county, vegetation now mainly are *Populus davidiana Sehrenk, Elacagnus angustifolia L, Tamarix ramosissima Ledeb, Sophora alopecuroides L, Salsola collina Pall, Artemisia, Achnatherum splendens Nevski, Karelinia caspia Less.*, *Aristolochia debilis Sieb.et Zucc, Ephedra Tourn ex L, Compositae, reed* etc; and *Alhagi pseudalhage Desv, Nitraria sibirica Pall and Calligonum mongolicum Turcz* etc at the Gobi to the south of the oasis.

Early in 1897, Denmark archeologist G.Saraun researched the turf layer near Copenhagen using the spore-pollen analyzing method [16]. This method is used broadly more and more in these 50 years. However, for the development of the spore-pollen subject, we can identify to plant family and can't to genus. In the fieldwork, most plants can be identified to genus. So, the plants distribute and water conditions near the sampling location can be figured out based on the spore-pollen analyzing results of the surface soil samples and the principle that the pollens of most plants will land near.

The pollens of shrubby and herbage plants are absolutely predominant, but the area distribute of *Ephedra, Chenopodiaceae* and *Artemisia* changes in evidence. We classed two pollen combinations based on the contents of droughty and salty Ephedra, Chenopodiaceae and Artemisia: Ephedra-Chenopodiaceae-Artemisia and Artemisia-Chenopodiaceae-Ephedra.

4.1.The environmental implication of the pollen combination of *Ephedra-Chenopodiaceae-Artemisia*

Look at sample 9, 11, 13. In this group, the pollen of shrubby *Ephedra* is predominant, high to 38.2%; the highest percentages of *Chenopodiaceae* and *Artemisia* samples are 27.4% and 21.0%. In order to validate the veracity of the pollen analysis, samples 9 and 13 repeated twice. The two samples was collected at the agrarian area of Xixia or Yuan dynasty at the north of Black City, this area was oasis at that time and sanded for the river changed its river way. The wind took the incompact accumulation in the surface away and only the hard soil and coarse accumulation remaining. So, the samples collected today aren't the original agrarian soil but the remaining soil altered by wind. From the pollen analysis result, we find the content of *Gramineae* is low and its individual is small, and the content of *Ephedra, Chenopodiaceae* and *Artemisia* is high. It shows that this area water condition is worse and the desert degree is serious. Sample 11 is the underwater deposit of the Suoguonuoer, but the water in it just came from the Heihe river a week ago and some droughty plants, Suaeda glauca Bunge, Nitraria sibirica Pall etc, just became green. The water conditions of the immovable and semi-immovable dunes near to the south and south-east of the lake and 30m out the lake bank are still worse.

4.2. The environmental implication of the pollen combination of *Artemisia- Chenopodiaceae- Ephedra*

Samples 2, 3, 4, 5, 6, 7, 8, 12, 14. The distributing area of these samples is better at the desert degree than samples 9, 11, 13. The pollen of *Artemisia* and *Chenopodiaceae* is predominant in shrubby and herbage pollen. The highest percentages of Artemisia, *Chenopodiaceae* and *Ephedra* are 40.5%, 41.2% and 16.7%, and there is pollen of sedge sometime, which likes wet circumstance. These phenomena show that this area is better at water condition and the desert degree isn't worse. This is in accordance with Mr. Yan Fuhua [17].

There are pollens of some woody plants, like *Pinus, Picea, Abies, Capressaceae, Betula* etc., in the surface soil, and these plants don't exist in the lower Heihe River now. We can conclude that these pollens are extraneous. As we all know, the pollen amount of *Pinus* and *Betula* big. The pollen of *Pinus* has air chamber and can fly 800km away with wind, and pollen of *Betula* 300km away [18]. The pollens of *Picea, Abies and Capressaceae* disperse around their matrix. These extraneous pollens may come from two places: pollens of *Pinus* [19] and *Betula* brought by the west and north-west wind from the Sky Moutain and Aertai Moutain; pollens of

Table 2 the spore-pollen statistics of the surface soil samples of lakes in the end of the lower Heihe River

Samples No.	1		2		3		4		5		6		7	
Particle number and percentage / Name	Numb-er	%	Numb-er	%	Numb-er	%	Numb-er	%	Numb-er	%	Numb-er	%	Numb-er	%
Sum of spore-pollen	7		306	100	252	100	272	100	178	100	282	100	270	100
Sum of arbor spore	0		10	3.3	17	6.7	20	7.4	7	3.9	21	7.4	20	7.4
Sum of shrubby and herbage spores	6		294	96.1	231	91.7	250	91.9	168	94.4	258	91.5	246	91.1
Sum of fern spores	1		2	0.6	4	1.6	2	0.7	3	1.7	3	1.1	4	1.5
Arbor spores														
Abies					1	0.4	2	0.7					1	0.4
Picea			2	0.6							1	0.4		
Pinus			7	2.3	12	4.8	13	4.8	4	2.2	11	3.9	12	4.4
Capressaceae			2	0.6			1	0.4	1	0.6	3	1.0	2	0.7
Betula					1	0.4					4	1.4		
Salix			1	0.3	1	0.4	1	0.4	1	0.6	2	0.7	1	0.4
Populus					2	0.8	3	1.1	1	0.6			4	1.5
Shrubby and herbage spores														
Corylus							1	0.4			1	0.4		
Ephedra			39	12.7	36	14.3	42	15.4	15	8.4	23	8.1	45	16.7
Leguminosae					15	5.9	13	4.8	12	6.7	4	1.4	21	7.8
Artemisia	2		103	33.7	75	29.7	63	23.1	48	26.9	41	14.5	73	27.0
Aster			2	0.6	2	0.8	1	0.4					1	0.4
Compositae	1		3	0.9	4	1.6	5	1.8	3	1.7	28	9.9	2	0.7
Chenopodiaceae	2		124	40.5	57	22.6	87	31.9	59	33.1	92	32.6	67	24.8
Caryophyllaceae			2	0.6	1	0.4	1	0.4			1	0.4		
Polygonum			4	1.2	3	1.2	5	1.8	2	1.1	6	2.1	2	0.7
Nitraria	1		5	1.6	4	1.6	6	2.2	3	1.7	5	1.8	3	1.1
Elaeagnus			2	0.6	7	2.8	4	1.5	3	1.7	2	0.7	1	0.4
Ranuncalaceae					1	0.4					1	0.4		
Cruciferae			1	0.3			1	0.4					1	0.4
Umbelliferae					1	0.4			1	0.5	1	0.4		
Thalictrum							1	0.4			1	0.4		
Tamarix			4	1.3	18	7.1	15	5.5	18	10.1	20	7.1	21	7.8
Myriophyllum											2	0.7		
Cyperaceae					1	0.4	1	0.4	1	0.6	2	0.7		
Gramineae			5	1.6	6	2.4	4	1.5	3	1.7	28	9.9	9	3.3
Pollens of fern														
Lycopodium					1	0.4							1	0.4
Selaginella	1		2	0.6	3	1.2	2	0.7	3	1.7	2	0.7	3	1.1
Filicales											1	0.4		

Appendix of table 2

Samples No.	8		9		10		11		12		13		14	
Particle number and percentage / Name	Numb-er	%	Numb-er	%	Numb-er	%	Numb-er	%	Numb-er	%	Numb-er	%	Numb-er	%
Sum of spore-pollen	249	100	178	100	27		278	100	238	100	62	100	241	100
Sum of arber spore	9	3.6	4	2.2	1		25	9.0	12	5.1	1	1.6	14	5.8
Sum of shrubby and herbage spores	238	95.6	171	96.1	25		251	90.3	225	94.5	60	96.8	225	93.4
Sum of fern spores	2	0.8	3	1.7	1		2	0.7	1	0.4	1	1.6	2	0.8
Arbor spores														
Abies	1	0.4					1	0.4	1	0.4			3	1.2
Picea	1	0.4					2	0.7	2	0.8				
Pinus	5	2.0	3	1.7	1		15	5.4	6	2.5	1	1.6	7	2.9
Capressaceae	1	0.4					2	0.7	1	0.4				
Betula	1	0.4	1	0.6			3	1.0	1	0.4				
Salix							1	0.4						
Populus							1	0.4	1	0.4			3	1.2
Shrubby and herbage spores														
Corylus							1	0.4						
Ephedra	29	11.6	68	38.2	6		75	26.9	26	10.9	21	33.9	39	16.2
Leguminosae	15	6.0	1	0.6			10	3.6	9	3.8	1	1.6	10	4.1
Artemisia	49	19.7	38	21.3	5		69	24.8	98	41.2	17	27.4	72	29.9
Aster							1	0.4						
Compositae	18	7.2	2	1.1			4	1.4	5	2.1	1	1.6	5	2.1
Chenopodiaceae	98	39.4	36	20.2	8		57	20.5	64	26.9	13	21.0	79	32.8
Caryophyllaceae							1	0.4						
Polygonum	4	1.6	2	1.1			3	1.0	2	0.8				
Nitraria	4	1.6	5	2.8	5		2	0.7	2	0.8	1	1.6	3	1.2
Elaeagnus	1	0.4	2	1.1			1	0.4					5	2.1
Ranuncalaceae									1	0.4				
Cruciferae							1	0.4						
Umbelliferae							1	0.4	1	0.4				
Thalictrum														
Tamarix	17	6.9	15	8.5			17	6.1	13	5.6	5	8.1	11	4.7
Myriophyllum														
Cyperaceae									1	0.4				
Gramineae	3	1.2	2	1.1	1		8	2.9	3	1.4	1	1.6	2	0.8
Pollens of fern														
Selaginella	249	100	178	100	27		278	100	238	100	62	100	241	100

Picea and *Capressaceae* brought by the Heihe River from the Qilian Mountain. The ratio of these extraneous pollens isn't big. Is it because the pollens in the mountain can't arrive here for the reduce of the water in Heihe River and the dry up of the lake? The current had been bigger before, are there more pollens of the mountain plants than surface soil? The research of the environmental implication of these *Picea* and *Capressaceae* pollens provides convincing evidence for the research of the spore-pollen in the lake center 2000 years ago [20].

4.3. The environmental implication of *Picea*

The diffuse ability of the *Picea* pollens are limited and most pollens will fall around the matrix [21]. Concluded according to the common sense, the *Picea* pollens in the riverbed of the East River (samples 8, 12), dust-color soil at the south to the center of Gashunnuoer Lake before the lake is lost (sample 2), underwater deposit of the Suoguonuoer (sample 11) and west to the Hang dynasty war flame ruin of marquis Zhenbei (diluvium, sample 6) may suggest that there should exist spruces before. But the fact is that there aren't spruces in the lower Heihe River in fieldwork. Analyzing the surface soil pollens of 14 samples, we find that there aren't *Picea* pollens in the riverbed soil in the droughty area of lower Heihe River beside the riverbed accumulation, Gashunnuoer and deposit of Suoguonuoer. I consider the *Picea* pollens in the riverbed and the lakes at the end of lower Heihe River the result of the transition of Heihe River and it doesn't represent the native vegetation. Its changes show the change of the plant and climate on the mountain and were tied up with the efficiency humidity. Its quantity represents the degree of the efficiency humidity.

4.4. The environmental implication of Capressaceae

Similar with *Picea, Capressaceae* pollens mainly come from mountain. *Capressaceae* can endure worse condition like droughty, cold and leanness than *Picea*. The demand of *Capressaceae* for circumstance is low and like droughty [5]. *Capressaceae* grow best when humidity is low and the period that the quality and variety of life-form is descending. When the humidity is descending, all plants are influenced; pollen produced decreased, spore-pollen concentration dropped. *Picea* and some wet-like plants are influenced greatly, they can't adapt the surroundings at all and the quantity descends sharply, and some species even die out. The quantity of *Capressaceae* descends, too, but the influence is smaller for its droughty endurance [2]. There aren't pollens of *Picea* or *Capressaceae* or some confiers in the samples (1, 10) from the ancient Juyanze, it shows the east ancient Juyanze has dried up and has no chunnel with Heihe River. There is a little water in the west ancient Juyanze because there is water from the middle Heihe River a week ago, but the velocity of flow descends rapidly, and the pollens from mountain accumulated at the lake center and the static and slow water area to its south side, but there aren't pollens at the north side.

5. Conclusion and discuss

(1) In the small semi-open basin research area, there is more substance exchange between the basin and its circumstance for the influence of water current, wind and some dynamical factors. So, the result is incredible if the ancient environment is rebuilt only based on the spore-pollen combination. We must consider the deposit circumstance and the spore-pollen transfer mechanism totally, recognize the source of the spore-pollen and its influence, and then, we can rebuild the ancient circumstance of the research river basin or the research point by the environmental implication the spore-pollen combination represents. Considering these factors together, we conclude that the spore-pollen records of the lakes in the end of the lower Heihe River not only show native vegetation status but also show the vegetation status of this river basin and on the mountain. The ratios of *Ephedra, Chenopodiaceae* and *Artemisia,* which are the predominant contents in the spore-pollen combinations, show the change of the efficiency humidity of this area. The combination of *Chenopodiaceae-Artemisia-Ephedra* reflects wet relative, and *Ephedra-Artemisia-Chenopodiaceae* reflects dry relative. In addition, the rations of *Picea* and *Capressaceae* show the change of the efficiency humidity too. The quantity of *Picea* reflects the humidity is high and the quantity of *Capressaceae* reflects low humidity.

(2) In the extremely droughty area, the main zoology factors that influence the growth and distribute are humidity and temperature influenced by the limen domino effect. The plants growth is sensitive to the change of humidity. When the humidity increases, the growth condition gets better, species variety added, plants grow better and the cover degree of the surface is high. When humidity descends, some species that like wet circumstance will die out or its range will shrink. The vegetation covering degree of the basin deduces sharply. The change of temperature will mainly influence the distributing of the plant belt and cause the move of the mountain plant belts. This won't change the vegetation compose of this river basin greatly. The surface soil spore-pollen combination reflects this character. The spore-pollen combination of *Chenopodiaceae-Artemisia-Ephedra* and the appreciate condition for *Picea* shows better water condition and the species variety increases; the spore-pollen combination of *Ephedra-Artemisia-Chenopodiaceae* and the appreciate condition for *Capressaceae* shows worse water condition and the species variety descends sharply. These conclusions are in accordance with Fuhua Yan and Yan Zhu [2, 17].

(3) There aren't bulrush spores in the 14 surface soil samples. Bulrush is a swampy 多年生 hydrophily plants, and distribute at the temperate zone and the torrid zone. It's common at the swamp and in the shallow water of the river [22]. Though there little water in the Suoguonuoer and Swan Lake from the middle Heihe River, the salinity is high and there isn't bulrush. But the bulrush content in the spore-pollen combination of the bore in the lake center can reflect the water condition and the question whether the lake deposit is continuous or not.

(4) The *Tamarix* distributed widely at the ancient Med Sea, and differentiated some young kinds to adapt modern desert climate [23]. The *Tamarix* and *Nitraria* distributed widely at the ancient Juyanze, their contents are important guideline of the climate and environment.

(5) The content of *Gramineae* spores is high to 9.9% in the diluvium west to the Hang dynasty war flame ruin of marquis Zhenbei. The contents of some individuals are higher than 9.9%, they seemed are cultivated. The plowland around the ruin (the concrete year unknown) maybe was destroyed by flood. Conclude from the nappe of the ground, however, the flood should be later than the ruin.

(6) At the extremely droughty area where wind is strong, if there is water in the river or lake or the soil is hard and the vegetation cover degree is high, the wind corrode underground can remain. But when the river or lake is dry or there no plants living, the wind corrode is serious, like the Yadan physiognomy at the ancient Juyanze. The content of *Gramineae* is low in the samples of the remaining agrarian soil of Xixia or Yuan dynasty at the north of Black City shows the original soil was corrode over or had been selected by the wind. So, at the droughty area where the wind corrode is serious, the question must be taken notice of that the wind corrode may cause the ages of the upper samples discontinuous in the lake center.

(7) There are difficulties in distilling the spore-pollen of the sand samples this time. Some conclusions are a little reluctant for the surface soil samples collected are little, and it should be discussed with the lucubration of the spore-pollen at the section of the lake center.

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