Palaeowind direction in Permian time

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Abstract Palaeowind directions are necessary to reconstruct provenance regions of deserts. U-Pb Detrital – Zircon geochronology and several dunes and dunetypes helping to reconstruct the source of sedimentary deposits like loessite and sandstone. Parts of heavy metals give information about the provenance of sands and forces of winds. With certain methods like High-Resolution Ion Microprobe zircon ages can be assigned which shows us the provenance of sediments and correlations between continents. Various dunes also indicate sources of sedimentary deposits. So geologists and palaeontologists are able to reconstruct form, dimension and first of all the location of a desert in the permian time on the supercontinent pangea.

Introduction

• In the upper Paleozoic eolian sand were transported by winds after they were eroded from the Mojave terrane. During the late Paleozoic there was the Ancestral Rocky Mountains orogeny. In the course of the time it was eroded and palaeowinds transported the sediments downwards which accumulated to huge sandy areas and builded deserts. Wind activities formed dunes and the sediments were deposited as loessit (eolian siltstone) and sandstones p.e.. The form and type of the dunes advertise the direction of winds. It evidences in which direction the sedimental dunes migrate. So it could be reconstructed in which direction deserts in this area will change and had changed before. With palaeowind direction it is possible to discover the correlation between several continents, model potential evolution of ancient deserts and model potential dispersion of existing deserts. Palaeowind directions can also be reconstructed by cross bedded sandstones and eolian sands. Detrital-Zircon geochronology and dunes are used for reconstruct palaeowind directions, sedimentary transport and its deposition. Several Loessites in the western USA could assigned to the Wolfcampian the early permian. They were related to the western equatorial Pangea.

Dune types and its dates

To find out palaeowind directions it is very important to analyse several dunes and its types. Sand dunes are educated at lee sides of barriers which create a slipstream. Grain of sand can deposit there and accumulate to a sanddune. If more sand deposit at the luff of the dune and less sand on the lee side is transported away than dunes will getting higher. Dunes in Saudi Arabia for example can achieve a height of 250 m. The types of sand dunes result from available amount of sand, direction, continuity and force of the wind. It can be distinguished between 7 different dune types.

Barchanes are the most common dunes. They form flat sandhills on a compact basement. Barchanes are generated if the amount of sand is low. The ends of barchanes points at the lee side of the dune because the sand is going to be transported slower in the centre than at the ends. So spiky flanks are build which are typical for this dune type. Barchanes can move up to 30 meters a year. The geometry of barchanes are similar. The luff rises up to 10 to 15 ° while the lee side of the dune decline with 30 to 35 °. The air which flows over the ridge is sinking. This causes curls which rotate in direction to the dune. The intralamination dip to the lee side.
If the underground is wet and overgrown parable dunes are formed. They accrue in semi-arid and humid areas. The vegetation cleaves the ends of the dune which points at the luff. The high centre camber with the wind forward because on the bank there exists no vegetation which could stop the sand transportation. The intralamination dip to the lee side.
When a huge amount of sand is available longitudinal dunes can accrue. They can get 100 metres high and up to 200 metres long. Longitudinal dunes run parallel to each other in distances up to two km. They exist already a very long time. During the last cold stage (10000 to 20000 years ago) this dunes were accumulated. It is supposed that counterrotating, helical air flows which consists of force horizontal winds and ascending hot air are responsible for this dune structure. For geomorphologists is also possible that this structure is caused by winds which are changing their direction seasonal. So the sand will rounded up and the dunes will string around the middle axes of both wind directions. The lamination of longitudinal dunes is irregular. Longitudinal dunes are more or less fixed.
Star dunes are pyramidal mega dunes with rays. They can rise up to 100 metres. The genesis is not explicit manifested but it is supposed that the wind direction often changes and the wind has to come from more than three different sides. This dunes can become more than 9000 years.
Transversal dunes consists of many barchane dunes which constitute irregular mountain ridges. Its longitudinal axis are transvers to the wind direction. Transversal dunes will be educate in arid areas where abundant sand is available and no vegetation exists. They develop if force onshore winds are blowing.

Sand which accumulate on desert plants like the “Naba-Melon” in the namib or the “Ziziphus” in tunesia is called nebka. These plants catch the grains of sand with their branched boughs. If the plants grow the nebka also rises up.
Lee dunes growing in the slipstream for example of a rock. The air which flows around this rock forms a sanddune with a towering ridge. Lee dunes are able to become several kilometers long depending on force of the wind, amount of sand and dimension of the rock.

All these dune forms were built by several palaeowinds which was evidenced by cross bedded sandstones, dune ripples or lacustrine wave ripples.

Using Zircons and eolian sands for desert reconstruction – two samples

Detrital Zircons from upper Palaeozoic loessite of western USA were used for U-Pb geochronology. With High-Resolution Ion Microprobe methods the zircon age spectra of four loessites from tree localities were under examination. Zircon has a high resistance to abrasion which is why it survives multiple erosion-deposition cycles. By using the CIA (chemical index of alteration) it was detected that the eolian silt from the western United States, and the zircons within it, is a first-cycle deposit.
The Zircons which were under examination represent two ages - the Wolfcampian and the Desmoinesian. The Desmoinesian samples match the regional basement of northern Arizona, northern New Mexico, and southern Colorado (Yavapai-Mazatzal provinces). It was uplifted by the Ancestral Rocky Mountains orogeny. Also, the Zircons from both samples match ages (1510 to 1395 Ma) of the granite-rhyolite basement terrane and the granitic plutons which are situated in the southwestern and midcontinental United States. The significant population in both samples grains (1300 to 900 Ma) seems to be from the Greenville basement terrane. It may have been derived from the basement in western or central Texas or northern Mexico. For the wolfcampian two samples were under examination, too. They are felsic metatuffs and associated plutonic rocks of the Carolina slate belt and/or plutonic and subordinate volcanic rocks of the Avalon terrane. This suggests a distal eastern source.

It is clear that all four of these samples were located in western equatorial Pangea. The sources of the zircons were regional basement uplifts of western and central equatorial Pangea. For wolfcampian time the detrital-zircon provenance data indicate easterly and westerly winds. Contrasting zircon age spectra reflect their locations on opposing sides of the main Ancestral Rocky Mountains. Some grains of the Utah sample possibly reflect derivation from western sources (Mojave terrane). The New Mexico sample accumulated east of the Ancestral Rocky Mountains because of westerly winds which would have provided silt from these uplifts. In Pangea northeasterly winds were dominating. In wolfcampian change in atmospheric circulation was inferred by the two wolfcampian samples.
Wave propagation direction, and therefore wind direction, can be deduced from the asymmetry of wave ripples and from the dip of their internal foresets that are induced by the superimposed unidirectional currents related to Stoke drift. As shown in this picture there were some deserts on Pangea in Permian time. Palaeowind direction also was reconstructed by wave ripples which have been identified in a Permian lacustrine basin which is located in the southern French Massif Central in the Lodève Basin. The morphology and the internal structure of ripples in the Salagou Formation reveals two types of ripples — wave ripples with a wavelength ranging from one to two cm and wave ripples with a wavelength ranging from two to 6 cm.

Type 2 symmetrical ripple with a rounded shape (wavelength $\frac{1}{4} - 4$ cm, amplitude 0Æ5 cm). Oscillatory flow direction is N035°.

Wave ripples generally develop in a direction which is vertical to wind directions. Waves may develop due to various processes such as wind, tsunami and seiching. Tsunamis produce large rare waves in response to large-scale, short duration disturbance of the bed or the water body.
Seiches result from a sudden rise or fall of water in enclosed or partially enclosed bodies, such as lakes, especially during local changes in atmospheric pressure. They can produce longshore drift effects. Waves produced by tsunamis and seiches vary in period from a few minutes to several hours. In the case of the Salagou Formation, palaeodepth calculations provide a maximum 5 sec wave period. Such a small value argues for waves that are driven by the wind, blowing across a limited fetch consistent with shallow lakes. The dominant wind direction during the Late Permian was north-northeast towards the south-southwest.

**Conclusion**

Palaeowind directions can be reconstructed on several ways. Mostly eolian sands and ripple structures are used for it. Loess and other sediments like sandstone helps to reconstruct wind directions and provenance of sediment depositions. To know the sources of sands is necessary if we want to reconstruct the palaeoclimat on earth and discover correlations between several continents.
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