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Dr Zongbo Shi PhD

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NERC Research Fellow

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About

Dr Zongbo Shi has a research interest in Atmospheric Aerosol Chemistry and Global Biogeochemical Cycles. He is currently funded by the NERC (Natural Environment Research Council) fellowship scheme;he also holds a Birmingham University Fellowship.

Qualifications

- PhD Environmental Sciences- China University of Mining and Technology (Beijing)
- BA Geology – Anhui University of Science and Technology, China

Biography

Zongbo Shi started his career as a geologist, gaining BA degree at Anhui University of Science and Technology, China. After studied for one and half years in Sedimentology in China University of Mining and Technology (Beijing), he was directly enrolled as a PhD student for his outstanding academic performance. During his PhD work, he investigated physicochemical properties and bioreactivity of urban aerosols and dust in Beijing. He then went to Tsinghua University working on fog and haze processing of primary particles (e.g., vehicle exhaust particles) and the sources of urban aerosols in Beijing, Shenzhen, and Ningbo. These works were part of the major air pollution mitigation consortium projects which developed air pollution control strategies in these cities. He was then granted a JSPS fellowship with a total funding of more than 1 million JPY to work in Prefectural University of Kumamoto, Japan where he focused on aging of the Asian dust and its impact on their chemical compositions and hygroscopic properties. Subsequently, he worked at School of Earth and Environment, University of Leeds to work on a NERC-funded project where he combined the knowledge in geochemistry with atmospheric sciences and global aerosol modeling to understand the atmospheric processing of iron and phosphorous in mineral dust.

He joined University of Birmingham in 2011 as a NERC fellow and also the first Birmingham Fellow. His current research aims at improving the estimation of the deposition fluxes of bioavailable iron, phosphorous and trace metals to the global ecosystems. This is approached by a combination of field measurements of atmospheric depositions and atmospheric aerosols, laboratory simulations of atmospheric processes, and global transport modeling simulations.

Teaching

Participate in teaching in

Air pollution chemistry for postgraduate students

GM221: Environmental Transfer Processes

Postgraduate supervision

We are regularly recruiting PhD students. If you are interested, please contact me for potential opportunities. International students are welcome to apply but we usually accept candidates with funding. There are funds available to candidates from China and Brazil. Interested candidates are welcome to contact me. Birmingham overseas elite PhD studentship is available to all overseas nationals.

New project available

http://www.findaphd.com/search/ProjectDetails.aspx?PJID=49444&LID=135 (http://www.findaphd.com/search/ProjectDetails.aspx?PJID=49444&LID=135)

Postdoc researchers are welcome to apply through various schemes available (**http://www.birmingham.ac.uk/schools/gees/research/fellowship.aspx (http://www.birmingham.ac.uk/schools/gees/research/fellowship.aspx)**).

2011-2013

- Matthew Taiwo, PhD candidate, University of Birmingham (co-supervise with Prof. R. Harrison)

2012-

- Adam Davies, PhD candidate, University of Birmingham (co-supervise with Prof. E Valsami-Jones and Prof. J. Lead), funded by NERC Analytical Science and Technology Scheme

2013-

- Nicholas Davidson, PhD candidate, University of Birmingham, Funded by NERC
- Zhe Tian, PhD Candidate, University of Birmingham,

2011

- Jenni Hopkins, Postgraduate research student, University of Leeds

2003-2005

- Yanju Chen, 3-year postgraduate research student, Tsinghua University
- Yan Liu, 3-year postgraduate research student, Tsinghua /Beijing Forestry University

PhD opportunities

Doctoral research

PhD title Physicochemical properties and bioreactivities of PM10 and PM2.5 in Beijing air

Research

Research interests include:

- Global Biogeochemical Cycles
- Atmospheric Chemistry
- Environmental Geochemistry

Current and completed projects

Novel approaches to the evaluation of iron and phosphorus availability in dust deposited to the oceans

(Funded by Natural Environment Research Council Fellowship Scheme, NE/I021616/1, 2011-2014)

Ocean is a major sink for atmospheric CO2. The carbon uptake capacity of a large part of the global ocean is however limited by the amount of nutrients iron (Fe) and/or phosphorus (P) in surface waters. Therefore, understanding the origins and fate of Fe and P in surface oceans is important in modeling the climate system and therefore predicting climate change. One of the primary external sources of Fe and P found in the surface waters in the open ocean is through atmospheric dust. Such Fe and P from the dust can increase ocean carbon uptake and alter ocean biogeochemistry, thus affecting climate.

The magnitude of the impact of dust input on oceanic carbon uptake and climate is dependent on total dust deposition fluxes as well as the bioavailability of Fe and P in the dust. Global models seem able to simulate the former reasonably well but not the latter. One important reason is that most Fe and P in desert dust are unreactive and thus not bioavailable but they can become much more reactive after being transported in the atmosphere. For example, the fraction of dissolved (<200nm) to total Fe and P (defined as solubility) are orders of magnitude higher in dust over more remote oceans than over desert regions. It is now understood that solubility of Fe, and probably P, in dust is controlled to a large extent by processes in the source area and in the atmosphere. Mechanistic understanding of some of the processes have been developed and/or parameterized into global models. However, major gaps remain on the solubility, lability and bioavailability of Fe and P in dust deposited to the ocean, particularly from the wet deposition. These gaps significantly affects the ability of global models to represent the current climate system and therefore to predict climate change.

The aim of this work is to evaluate the solubility and lability (availability) of Fe and P in dust, particularly in rainwater deposited to the oceans. The objectives are:

(1) To elucidate the fundamental parameters and processes controlling the concentration and partition of labile, soluble (<1nm), dissolved, and total Fe and P in dust from rainwater;
(2) To clarify how Fe interact with P and trace metals in rainwater and affect their solubilities;
(3) To quantify the labile and/or soluble, dissolved and total Fe and P deposition fluxes at five sites downwind of dust source regions for model constraining.

These objectives will be met by field measurements and laboratory simulations employing state-of-the-art separation techniques (e.g., flow field flow fractionation, FFF) and *in-situ* labile trace metal speciation techniques (i.e., diffusive gradients in thin Films, DGT) coupled with high resolution ICP-MS and Electron and Atomic Microscopy. The scientific results will be fed to global models to improve the estimation of atmospheric nutrient deposition fluxes, and can be readily fed to Met Office and NERC Earth system models to predict the impact of atmospheric nutrient input on ocean productivity and climate in the present and the future**.**

Developing new understandings of the fundamental pathways of Fe in mineral aerosols from Saharan soils to the marine ecosystem in surface seawater

(Funded by Natural Environment Research Council, NERC SOLAS project NE/E011470/1, 2007-2010)

This project was funded by NERC and was led by Professor Mike Krom at University of Leeds. A number of geochemists, modellers and atmospheric scientists are involved in this work including Professor Ken Carslaw, Professor Liane Benning, Dr. Graham Mann, Dr. Matt Woodhouse and Dr. Steeve Bonneville (now at Belgium) from University of Leeds and Professor Tim Jickells and Dr. Alex Baker from University of East Anglia. The purpose of this project was to understand how processes in the dust source regions and in the atmosphere change the speciation and solubility of Fe (and P) in the dust aerosol.

We showed that a significant fraction of the Fe in Saharan dust samples can be dissolved at low (e.g. 2) and high ionic strength relevant for the conditions in natural and polluted aerosols. However, such dissolved Fe can precipitate as bioavailable Fe nanoparticles once the aerosols were processed in simulated clouds with an intermediate pH commonly found in the natural cloud droplets. We found that over 2.5% of Fe was determined as ferrihydrite nanoparticles in the Saharan dust samples in the wet depositions (Shi et al., 2009, EST). This “new” source of bioavailable Fe has to be taken into account in future earth system models. We also carried out detailed kinetic work to determine the pH dependent Fe dissolution kinetics and to understand the underlying differences in Fe reactivity in dust aerosols. We have found that Fe in dust aerosols can be represented by three different phases with widely different Fe dissolution kinetics. We have shown that the dust/water ratio is crucial and that under normal ratios found in the atmosphere only the ‘fast’ pool reacts and suppresses the dissolution of the intermediate and slow pools (Shi et al., 2011, ACP). New data on the size distribution of Fe solubility in dust aerosols generated from soil samples collected in major dust source regions have been combined with GLOMAP-output size-resolved dust mass size distribution over the north Atlantic Ocean to test the physical size sorting hypothesis proposed by Baker and Jickells (2006, GRL). We have confirmed that physical size sorting alone is not important in increase the Fe solubility in the dust during transport (Shi et al., 2011, ACP).

In subsequent experiments we found that chemical weathering processes in the source areas are important controls on potential Fe solubility of mineral dusts. We observed a regional variability in chemical weathering and Fe oxide aging across N Africa. For example, the paleolakes in Libya supply dust with relatively high potential Fe solubility while areas of the Sahel where the weathering has resulted in more mature and aged Fe oxides have lower potential Fe solubility. We have shown that the ratio of nanoparticulate and amorphous Fe to crystalline Fe oxides or the Parker weathering index are much better predictors of potential Fe solubility in dust than the methods (e.g. Haematite and/or summing the reactivity of individual pure minerals) which are used in present regional and global models (Shi et al., 2011, GBC).

We are also involved in a new research area of global importance: the role of atmospheric processing of dust in P biogeochemical cycle. It has been found that there has been a tenfold increase in bioavailable P when Saharan soils and dusts were acidified in atmospheric simulation experiments. This supported by field observations which shows that soluble P concentration in the dust aerosols in Crete increased with acidity in the aerosols (Nenes et al., 2011, ACP). Our results link the supply of bioavailable P to the oceans to emissions of natural and anthropogenic acidic gases, and hence represent a potentially key mechanism regulating global ocean biogeochemistry. This work is also expected to be relevant to the role of volcanism on ocean anoxia in geological past.

Funding awards

- **NERC Fellowship award**: £379 509, 2011-2014
- **NERC New Investigator award**: £97k, 2013-2014
- **Birmingham University Fellowship award**: 2011-2016

- **NERC Analytical Science and Technology Directed Research Studentship award**: 70k, 2012-2016
- **ATMOMED mesocosm project** (PI on dust characterization), European Union Seventh Framework Program (FP7/2007-2013) under grant agreement n° 228224, MESOAQUA: 2012
- **ACTRiS** (Aerosol Clouds, and Trace gases Research InfraStructure network) training award: 2012
- **NERC Public Engagement Funding award**, 2012
- **JSPS Fellowship award**: ~¥11 000 000=~£8 3570, 2005-2007
- **NSFC standard award**: ~£25 000, 2004-2007

Other activities

European Association of Geochemistry: member

NERC peer review college: member

AAAS: selected member for the Excellence in Science program

REVIEWER of US Natural Science Foundation (NSF) and Czech Science Foundation

REVIEWER OF JOURNALS: Natural Geosciences; Environmental Science & Technology; Journal of Geophysical Research-Atmosphere; Atmospheric Chemistry and Physics; Chemosphere; Atmospheric Environment; Tellus-B; Environmental Chemistry etc.

Publications

Main Publications since 2003

- **Shi, Z.**, Krom, M., Jickells, T., Bonneville, S., Carslaw, K.S., Mihalopolous, N., Baker, A.R., Benning, L.G., 2012. Impacts on iron solubility in the mineral dust by processes in the source region and the atmosphere: A review. ***Aeolian Research***, 21-42, **http://dx.doi.org/10.1016/j.aeolia.2012.03.001 (http://dx.doi.org/10.1016/j.aeolia.2012.03.001)** .
- Yang, F., Tan, J., **Shi, Z.B**., Cai, Y., He, K., Ma, Y., Duan, F., Okuda, T., Tanaka, S., Chen, G., Bai, L., 2012. Five-year record of atmospheric precipitation chemistry in urban Beijing, China.***Atmospheric Chemistry Physics, 12, 2025-2035,*** **http://dx.doi.org/10.5194/acp-12-2025-2012 (http://dx.doi.org/10.5194/acp-12-2025-2012)** . , 12, 2025-2035, .
- He, K., Zhao, Q., Ma, Y., Duan, F., Yang, F., **Shi, Z.B**., Chen, G., 2012. Spatial and seasonal variability of PM2.5 acidity at two Chinese megacities: insights into the formation of secondary inorganic aerosols. ***Atmospheric Chemistry Physics***, 12, 1377–1395, **http://dx.doi.org/10.5194/acp-12-1377-2012 (http://dx.doi.org/10.5194/acp-12-1377-2012)** .
- **Shi, Z.**, Woodhouse, M., Carslaw, K., Krom M., Mann, G., Baker A., Savov, I., Fones, G., Brooks, B., Drake, N., Jickells T., Benning L., 2011, Minor effect of physical size sorting on iron solubility of transported mineral dust, Atmospheric Chemistry and Physics, 11, 8459-8469, doi:10.5194/acp-11-8459-2011.
- Nenes, A., Krom, M., Mihalopoulos, N., Van Cappellen, P., **Shi, Z.**, Bougiatioti, A., Zarmpas, P., Herubt, B., 2011. Atmospheric acidification of mineral aerosols: A source of bioavailable phosphorus for the oceans. Atmospheric Chemistry and Physics, 11, 6265–6272, 2011, doi:10.5194/acp-11-6265-2011.
- **Shi, Z.**, Krom, M., Bonneville, S., Baker, A., Bristow, C., Drake, N., Mann, G., Carslaw, K., McQuaid, J., Jickells, T., Benning, L., 2011. Influence of chemical weathering and aging of iron oxides on the potential iron solubility of Saharan dust during simulated atmospheric processing. Global Biogeochemical Cycles, 25, GB2010, doi:10.1029/2010GB003837.
- **Shi, Z.**, Bonneville, S., Krom, M., Carslaw K., Jickells, T., Baker, A., Benning, L., 2011. Dissolution kinetics of iron in the mineral dust at low pH during simulated atmospheric processing. Atmospheric Chemistry and Physics, 11, 995-1007, **doi:10.5194/acp-11-995-2011 (http://www.atmos-chem-phys.net/11/995/2011/acp-11-995-2011.html)** .
- **Shi, Z.**, Krom, M., Bonneville, S., Baker, A., Jickells, T., Benning, L., 2009. Formation of iron nanoparticles and increase in iron reactivity in the mineral dust during simulated cloud processing. Environmental Science & Technology, 43, 6592-6596, doi: 10.1021/es901294g.
- **Shi, Z.**, Zhang, D., Hayashi, M., Ogata, H., Ji, H., Fujiie, W., 2008. Influences of sulfate and nitrate on the hygroscopic behaviors of coarse dust particles. Atmospheric Environment, 42, 822-827, **doi:10.1016/j.atmosenv.2007.10.037 (http://doi:10.1016/j.atmosenv.2007.10.037)** .
- **Shi, Z.**, Shao, L., Jones, T. P., Lu, S., 2005. Microscopy and mineralogy of airborne particles collected during severe dust storm episodes in Beijing, China. Journal of Geophysical Research, 110, D01303, **doi:10.1029/2004JD005073 (http://doi:10.1029/2004JD005073)** .
- **Shi, Z.**, Shao, L., Jones, T.P., Whittaker, A.G, Lu, S., Bérubé, K.A., He, T. and Richards, R. J., 2003. Characterization of airborne individual particles collected in an urban area, a satellite city and a clean air site in Beijing, 2001. Atmospheric Environment,37, 4097-4108, **doi:10.1016/S1352-2310(03)00531-4 (http://dx.doi.org/10.1016/S1352-2310(03)00531-4)**

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