

Effect of large earthquakes on the ionosphere

-Lithosphere/Atmosphere/Ionosphere Coupling-

Oyama, K.- I

oyama@pssc.ncku.edu.tw/koh_ichiro@yahoo.co.jp

**Plasma and Space Science Center, No.1 University Rd,
Tainan ,70101, Taiwan**

**International Center for Space Weather Study and
Education, Kyushu University, Japan**



Recent Reports on Precursor Phenomena of ionosphere/atmosphere of Large earthquakes

Ground Observations

foF2 :Liu et al., 2006, Maekawa et al., 2006; Hobara and Parrot , 2005;Zhao et al., 2008, Liu et al., 2009, Sharma et al, 2008

VLF propagation: Hayakawa et al., 2006, Rozhnoi et al., 2007

TEC: **Zakharenkova et al., 2007**

Atmospheric glow, Mikhalev et al., 2001

Satellite Observations

Ne Pulinets, Te Sharma et al.,JATP 2006

VLF wave; DEMETER, MidInfrared (11-12 μm) Emission: Ouzounov et al, 2006

O⁺, He⁺ ion composition:Bankov et al., 2009, Smatra

Particle precipitation: Rothkaehl et al., 2006, **Aleksandrin et al.,Ann.Geophys, 2003**

Ground / Satellite combination

Oyama et al., 2008 Te/ foF2 , Akhoondzadeh et al., 2010 Ne / satellite GPSTEC, Samoa Island (29.Sep, 2009 and 3 others) , Pulinets et al.,

Computer simulation : Klimenko et al., Proc.XXXII Annual Seminar,2009

Namgaladze et al., Geoman.Aernom., 49, 252-262, 2009

, gravity wave . Kuo etal., 116,A10317, 2011,JGR,Kuo and Lee 2014,will be published

Most of these works were conducted by the scientists whose long time research carrier is not related to ionosphere.

MTI group who have excellent ionosphere/thermosphere scientists are encouraged to spend some time for the precursor features of large earthquake.....

Satellite constelaltion

An Introduction to Space Instrumentation

Edited by
K. Oyama and C. Z. Cheng



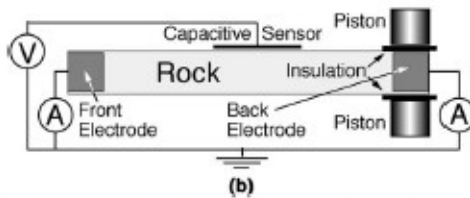
SBN No.: 978-4-88704-160-8
Publication date: 2013, Hard cover,
TERRAPUB, Tokyo
240+viii pp.
¥15000 (Incl. postage)

Contents

Preface	v
In-situ density measurements in the mesosphere/lower thermosphere region with the TOTAL and CONE instruments	1
..... B. Szelinikov, M. Rapp, and F.-J. Lübkin	
Atomic oxygen measurement by resonance lamp	13
..... N. Iwagami and W. H. Morrow	
Nitric oxide measurement by self-absorbing gas cell	17
..... N. Iwagami	
Imaging attitude finder for a sounding rocket and magnesium ion imager for airglow spatial pattern .. N. Iwagami, Y. Koizumi-Kurihara, and J. Kurihara	21
Airglow photometers on board sounding rockets	25
..... B. R. Clemesha, H. Takahashi, A. Eras, N. B. Lisboa, and D. Gobbi	
N_2 Temperature of Vibration instrument for sounding rocket observation in the lower thermosphere	33
..... J. Kurihara, N. Iwagami, and K.-I. Oyama	
Foil-chaff ejection systems for sounding rocket measurements of neutral winds in the mesopause region	41
..... Y. Koizumi-Kurihara, J. Kurihara, Y. Murayama, and K.-I. Oyama	
Wind measurements: Trimethyl aluminum (TMA) chemical release technique M. F. Larsen	47
Rocket-borne Lithium ejection system for neutral wind measurement	53
..... H. Habu, M. Yamamoto, S. Watanabe, and M. F. Larsen	
Langmuir probe	63
..... T. Abe and K.-I. Oyama	
Rocket-borne Langmuir probe for plasma density irregularities	77
..... H. S. S. Sinha	
Electron temperature probe	91
..... K.-I. Oyama and C. Z. Cheng	
Impedance probe technique to detect the absolute number density of electrons on-board spacecraft	107
..... M. Wakabayashi, T. Suzuki, J. Uemoto, A. Kamamoto, and T. Ono	
Resonance cone probe for measuring electron density, temperature, drift speed and beam components	125
..... A. Piel	
Retarding Potential Analyzer (RPA) for Sounding Rocket	139
..... H. K. Fong and C. Z. Cheng	
Electric field instrument onboard Japanese sounding rockets	155
..... K. Ishizaka	
Magnetic Field Measurement (MFM) and Sun Aspect Sensor (SAS)	165
..... T. Takahashi	
Designing a toroidal top-hat energy analyzer for low-energy electron measurement	181
..... Y. Kazama	
Low energy particle spectrometer for 3-axis stabilized spacecraft	193
..... Y. Saito	
Imaging thermal ion mass and velocity analyzer	203
..... A. W. Yau, E. P. King, P. Anierl, K. Berg, G. Enno, A. Howarth, I. Wevers, and A. White	
Development of fluxgate magnetometers and applications to the space science missions	217
..... A. Matsuoka, M. Shinohara, Y.-M. Tanaka, A. Fujimoto, and K. Iguchi	
Plasma wave receivers for scientific satellites	227
..... H. Kojima	
Acknowledgments	239



(a)



(b)

Fig. 1. (a) Granite slab placed in the press, ready for the uniaxial compression tests. The granite slab (1.2 m long, $10 \times 15 \text{ cm}^2$ cross section) is fitted with two Cu electrodes (each $30 \times 15 \text{ cm}^2$), one at the back end and one at the front end, plus a non-contact capacitive sensor for measuring the surface potential. The rock is insulated from the pistons and the press by 0.8 mm thick polyethylene sheets ($>10^{14} \Omega \text{ cm}$). (b) Block diagram of the electric circuit for allowing the self-generated currents to flow out of the stressed rock volume.

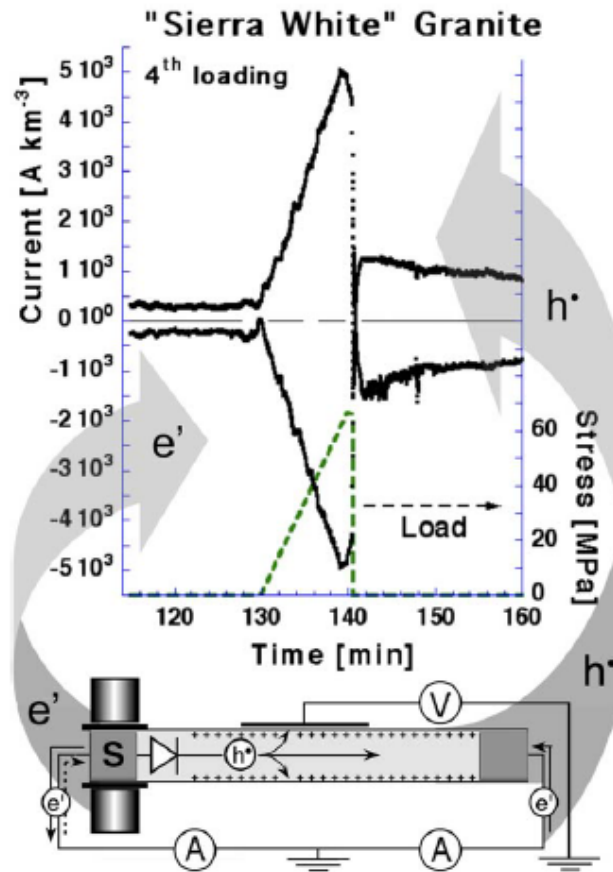


Fig. 2. Two currents flowing out of the stressed rock volume, the “source” S, and a schematic representation of the current flow through the external circuit and inside the rock passing through the interface between stressed/unstressed rock which acts as a barrier for electrons.

Physics and Chemistry of the Earth 31 (2006) 389–396

Electric currents streaming out of stressed igneous rocks A step towards understanding pre-earthquake low frequency EM emissions

Friedemann T. Freund^{a,b,*}, Akihiro Takeuchi^{b,c}, Bobby W.S. Lau^b

Final goal

To establish morphology on earthquake effects ,
methodology to predict earthquake occurrence

;

Ground based observations ;need model which can
reflect geomagnetic disturbance , as a first step—

1. Is accuracy enough , Maximum deviation from average
is about 20%).

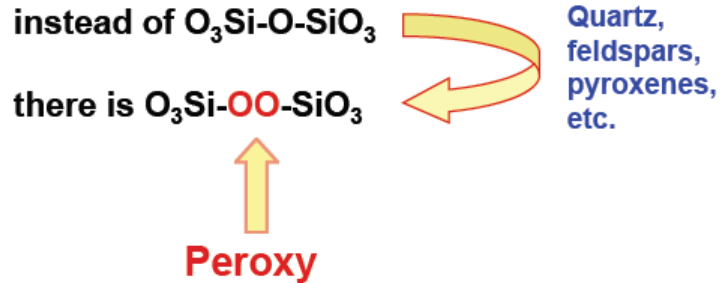
2. Observation side is not sufficient.

3. Only Japan has long term systematic
observation(SPIDER).

Coordination of satellites !!!

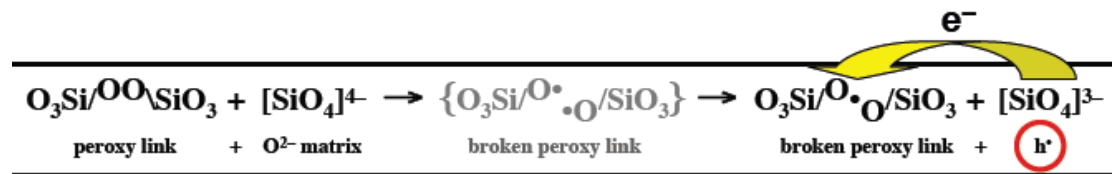
Fundamental Solid State Defect

Oxygen anions in minerals
in igneous and high-grade metamorphic rocks
exist in the valence 1-
(instead of the usual 2-)



Peroxy is a diamagnetic point defect
about 100-1000 ppm

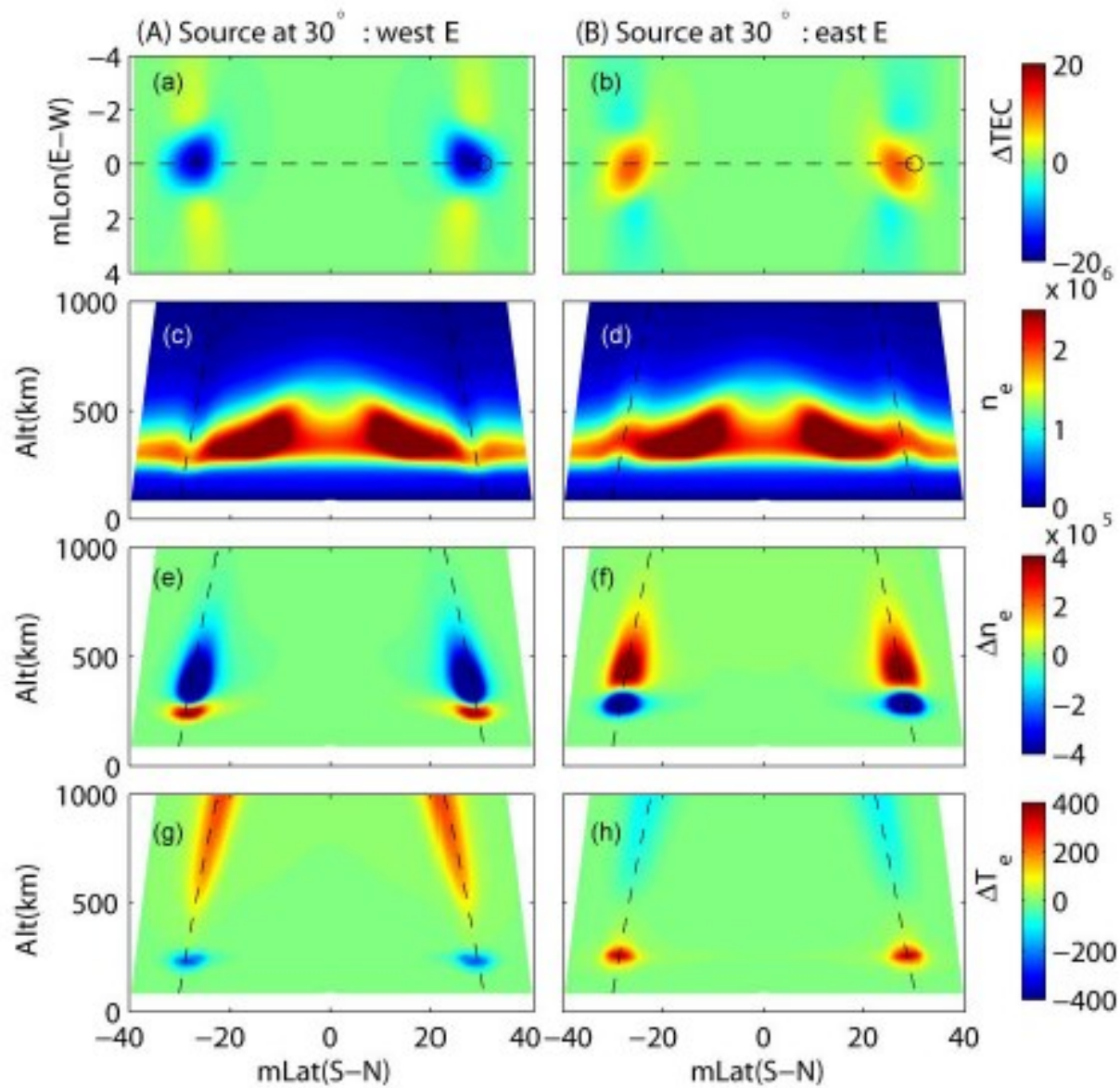
When stresses are applied, dislocations move



↑
Dislocations cut
through grains

↑
Dislocations break
peroxy links

↑
Electron transferred
from neighboring O²⁻
generates an O⁻



Kuo-et al, 2014 JGR

The space projects where the ionosphere observation and the earthquake precursors were studied

- **Alouette - 1964**
- **Cosmos-274 -1969**
- **OGO-6 - 1969**
- **OVI-17 - 1969**
- **ISIS-2 – 1971**
- **AE-C -1973**
- **GEOS-1 and 2 - 1978**
- **Intercosmos-19 – 1979**
- **Aureol-3 –1981**
- **Intercosmos-Bulgaria 1300 – 1982**
- **Salyut-7 - 1985**
- **Meteor-3 - 1986**
- **Cosmos 1809 -1987**
- **ISIS-2 – 1971**
- **Activny -(Intercosmos-24) -1989**
- **TOPEX/Poseidon - 1996**
- **GEOS-1 and 2 - 1978**
- **MIR Space Station**
- **DE-2**
- **Quakesat**
- **DEMETER**

Abnormal behavior of Ne, atmospheric glow, TEC, VLF, ion composition and particle precipitation have been reported ,which might have been associated with earthquake. We report at the beginning the ionosphere result from Hinotorori satellite