Petrology and mineral chemistry of the eniched basaltic shergottite Northwest Africa 8656. Ting Cao[1] (tingcao.dou@foxmail.com) and Qi He[1], [1] Planetary Science Institute,School of Earth Sciences, China University of Geosciences, Wuhan 430074, China.

Introduction: Our knowledge of Mars, especially the interior magmatic evolution, was sketchy before the study of Matian meteorites, which mainly provides clues about the history of Mars. The various types of martian meteorites suggest the multiple source reservoirs and complex mantle magma dynamics.The Northwest Africa 8656, basalt shergottite, is the sample of this study.The chemistry composition reveals the origin of magma and crystallization history, similar to other rich basaltic shergottite [1].

Methods: The characterization of primary petrography and mineralogy was finished by a field emission scanning electron microscope at China University of Geosciences,Wuhan and futher analysis of major-element compositions were measured by electron microprobe at China University of Geosciences,Wuhan and Wuhan University of Technology.Backscattered electron images and X-ray maps were collected for basic elements, Si, Fe ,Mg ,Ca and Al.The microprobe was calibrated using both synthetic and natural standards. A 15keV accelerating voltage, 20 nA beam current, 1μm beam spot was used to analyze most silicate and oxide minerals, but 5μm for phosphates,maskelynite and glassy phases to avoid the loss of Na and K.

Petrography: NWA8656 is a medium-grained ophitic rock, predominantly consists of clinopyroxene and plagio clase crystals. Clinopyroxene(~63vol%) appears as euhedral to subhedral, elongated prismatic grains and up to 2.5mm in size,which can be regarded as phenocryst. Subhedral lath-shaped plagioclase (~31 vol%) is interstitial to pyroxene and up to 1.3mm in size. However, they has been completely converted into maskelynite because of shock metamorphism. Accessory mineral includes Fe-Ti oxide (~3vol%), phosphate(~2vol%),glass, and troilite(Fig.1).Exsolution texture is widespread occured in ulvospinel grains and ilmenite is attached as the exsolution product. Symplectite is a kind of very common assemblage that fayalite and pyroxene homogenous intergrowth with glassy silica around the junction, or silica intergrowth with fayalite,which formed mymekitic symplectite [2] . The formation of them is considerated to be decomposition of rich-Fe pyroxene. The shock melt pockets are aboundant in this sample.

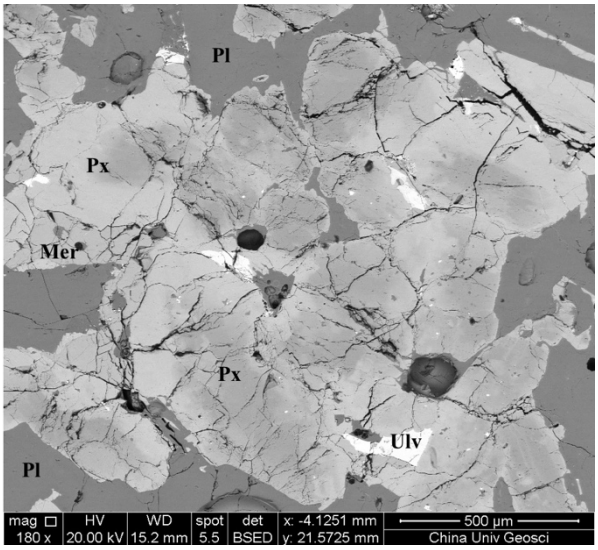

Fig.1 Backscattered image of NWA8656. Different minerals are marked by the differnent symbols. 1)Px-pyroxene, 2)Pl-plagioclase, 3)Ulv-ulvospinel ,4)Mer-merrillite.

Mineral Chemistry: Mineral chemistry analysis has revealed the coexisting of two different pyroxenes, augite and pigeonite. All of them show a complex composition zoning from core to rim.The composition zoning ranges from $En_{44}Wo_{33}$ to $En_{25}Wo_{33}$ for augite, while from $En_{55}Wo_{12}$ to $En_{20}Wo_{14}$ for pigeonite (Fig.2).Generally, the evolution trend varied from Mg-rich to Fe-rich. Few pyroxferroite grains can be found in Fe-Ti oxide margin. Plagioclase is mainly characterized by compositions of An_{55-53} Or_{1-3}.Phosphate contains merrilite and apatite, while Fe-Ti oxides are ulvospinel and ilmenite.

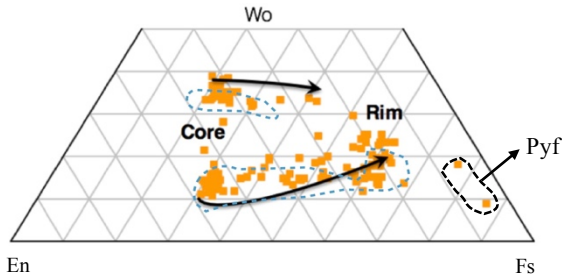

Fig.2 End-member components of NWA 8656 pyroxene. Arrows represent composition variation range and evolution trends, blue dotted lines outline Shergotty composition [1]. Pyf-pyroxferroite.

Result: Different pyroxenes and different zoning patterns of them all can be definitely discerned in X-ray maps. Mostly, pigeonite presents as crystals with a zoning from Mg-rich to Fe-rich, while augite is partially rimmed by ferroan pigeonite (Fig.3) [1,3,4]. Plagioclase is interstitial to pyroxene with homogenous composition.

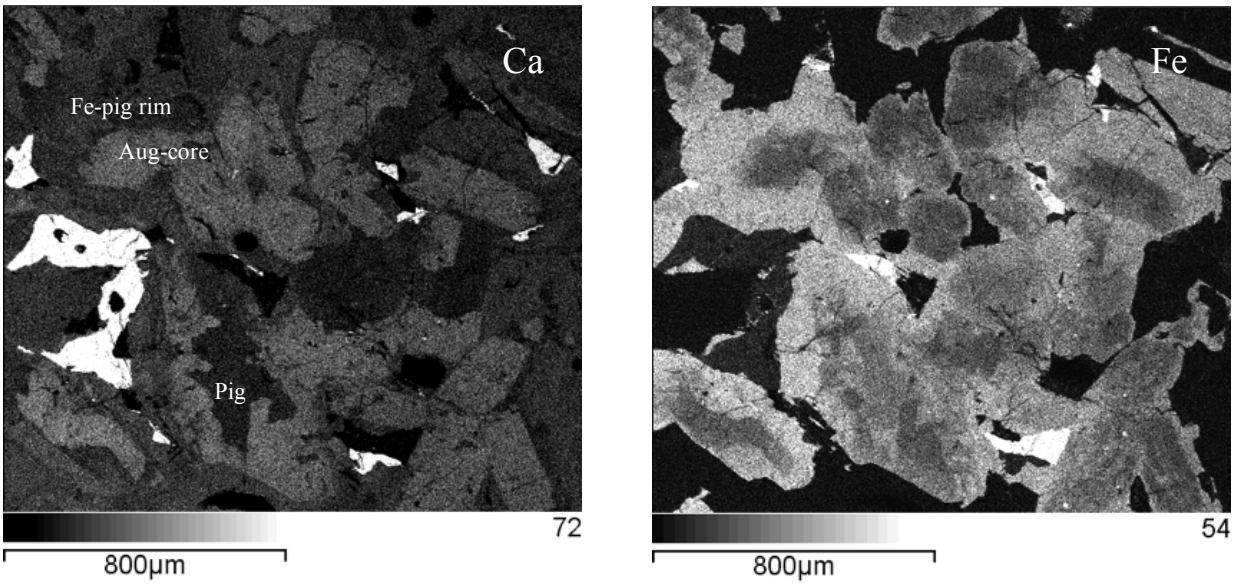

Fig.3 X-ray maps of Ca and Fe in NWA8656.Augite and pigeonite are marked by differnent symbols.

Crystallization History: The crystallization sequence is definitely inferred by the value of Al, Ti and Al/Ti ratio [5,6,7].Major element data of pyroxene was used to calculate the value of Mg# and Al/Ti ratio. The value of Mg# is decreasing along the evolution direction, meanwhile Al/Ti ratio presents a diminishing curve. It can be interpreted as a result that differnent minerals were involved in crystallization processes. Firstly, the formation of plagioclase goes with depleting Al, which explains the reducing of Al/Ti ratio from 6 to 2, while Mg#60 to 35. Secondly, the formation of Fe-Ti oxide represents the depletion of Ti, so the covariation of both Al and Ti illustrates the gentle curve for the value that is around 1.5, between Mg#20 to 35 (Fig.4).

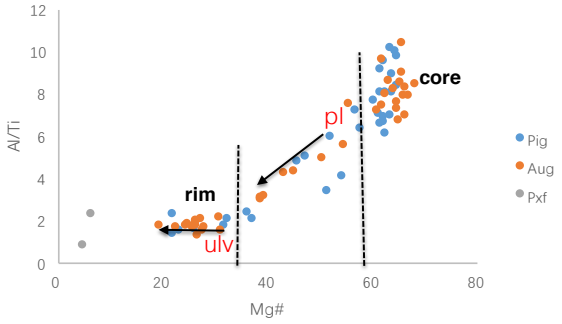

Fig.4 The diagram of atomic Al/Ti ratio versus Mg# for pyroxene in NWA 8656.

Summary: Comparing with other enriched basaltic shergottites, NWA 8656 shows similar petrological characteristics. The magmatic evolution has been proposed, 1) Mg-rich pyroxene always present as core of single grain.The complex zoning of pyroxene indicate the coexisting of pigeonite and augite that augite is partially rimmed by ferroan pigeonite [1,3]. 2) plagioclase acts as the following crystallization mineral of pyroxene, and then ulvospinel accesses to the crystallization processes. Lastly, these three mineral phases,maybe also merrillite, crystallize together until the end [3,5,7]. 3) the existence of maskelynite and impact pocket indicate the pressure of shock metamorphism can up to 30GPa.

References: [1] Takashi Mikouchi. and Masamichi Miyamoto. (1999) *Earth and Planetary Science Letters, 173,* 235–256. [2] Aramovich C. J. et al. (2002) *American Mineralogist, 87,1351–1359*. [3] McSween H. Y. et al. (1994) *Meteoritics Society, 29,757–779*. [4] Barrat. J.A. et al. (2002) *Meteoritics & Planet. Sci, 37,487–499*. [5] Yang L . et al. (2009) *Meteoritics & Planet. Sci., 44,261–284*. [6] Hejiu H. et al. (2011) *Meteoritics & Planet. Sci, 46,1313–1328*. [7] Mahesh Anand. et al. (2006) *Geochimica, 70,246–264*.