IMPACT-RELATED EVENTS ON ACTIVE TECTONIC REGIONS DEFINED BY ITS AGE, SHOCKED MINERALS AND COMPOSITIONS. Y.Miura, A. Hirota, M. Gorton, and M. Kedves. Department of Earth Sciences, Faculty of Science, Yamaguchi University, Yoshida 1677-1, Yamaguchi 753-8512, Japan. yasmiura@po.cc.yamaguchi-u.ac.jp

Introduction: Crater "MKT" used in this paper is Miura (Kagawa-Takamatsu) crater located in Takamatsu, Kagawa Prefecture, Shikoku, Japan is a buried circular feature defined by ca. 4-km diameter [1,2] with negative gravity anomaly and by ca. 8km semi-circular structure in an area of Late Cretaceous (ca.90 Ma) Rhyoke granitic rocks [3-9]. Main purpose of the present paper is to propose definition of impact-related event on volcanic and tectonic regions by using bulk compositions, aging, shocked materials of shocked quartz minerals with linear and cross-lamellae, and Ni-rich particles [9].

Definition of impact-related events on volcanic and tectonic islands: Almost all impact craters with shocked materials are defined on stable continents which basement are not moved or changed through long terrestrial surface history by plate-tectonics or continental drift. Volcanic and tectonic regions mainly at margin of the continents or islands, however, reveal significant change and moving with breaking and reconstruction by volcano, landslide and earthquake. It is, therefore, difficult to use all the same impact signature to candidate of impact crater at volcanic and tectonic islands (along old and new subduction regions). In fact, almost all impact craters on stable continents where it was considered to be volcanic origin at first, are redefined as impact craters mainly because of few volcano around the impact craters. We require more detailed data of impact craters if we propose new impact crater in tectonic regions as the following proposed indicator and evidence of impact crater in volcanic islands.

1) Obvious difference of aging data connected to impact and volcanic event with older impact age. On the Takamatsu MKT crater, U-Pb zircon dating data of related rocks in the crater are "granitic rocks" of basements (80-97Ma) or "spherule" formation event formed by impact ejecta (15.3Ma) [3-9]. There are no fragments and brecciated rock with the same aging data of Setouchi volcanic event (14 to 12 Ma [2]) in such zircon data of the MKT crater. Therefore, K-Ar dating of related rocks in the crater reported by Japanese volcanologists [2] as possible large volcanic event (ca.14Ma) to form large rhyolitic rocks is considered to be followed volcanic and hydrothermal activities on the active islands of Japan [8,9]. The formation of "the Sea of Japan" and "the Seto- Inland Sea" covers the original crater resulting in "buried or broken semi-circular crater" [3-9].

2) Minor and clear evidence of impact event in bulk chemical compositions and shocked minerals. In general, it is difficult to find large amounts of clear impact data and materials on active tectonic regions as Japanese islands. Therefore, impact-related data and materials on the severe tectonic regions, are considered to be minor and small mainly because of strong crushing process followed by volcanic intrusions, earthquakes and landslides [3-9]. The following five indicators are strong evidences to define impact-related crater in active islands or continental margins.

a) Gravity anomaly: There is negative gravity anomaly on ca.4km [1], though there is larger ca. 8km semi-circular structure from satellite-image and topological data without clear gravity anomaly [3-9]. The large semi-circular structure is considered to be broken by later tectonics (Fig.1).

b) Clear difference of impact age with later volcanic event: Although K-Ar dating of crater rocks and sediments shows age of the Setouchi volcanic event (14 to 12 Ma) which is considered to be "metamorphic" event (not large volcanic event), but the stable age of zircon data in the MKT crater is U-Pb dated at 15.3 (±0.3) Ma inferred to be the age of the crater structure which is determined by zircon fragment included in glassy spherule shown in Fig.2 [3-9]. The glassy spherule with granitic composition indicates that impact event might be produced on the granitic target rocks near the of the old continents before forming the Sea of Japan, where large crater structure was considered to be broken at the formation of the Seto-Inland Sea.

c) Different bulk compositional data of impact-related rocks and volcanic rocks: All rock types of buried crater with covered sediment and small intrusions can be checked by the XRF bulk data. In fact, there are clearly basement rock of granites and ryolitic rocks on the MKT crater [9].

From XRF data, there are *three types of granites*. (1) Granitic rock-1: located at the Inner ring of 4km as sample No.TK15, and at the outer ring of 8km as sample TK13, 22 which is old Rhyoke granite type (ca.90Ma). (2) Granitic rock-2: found at the Inner ring of 4km as sample No.TK15, which is close to granitic type breccia-1. (3) Shocked granite block: exits at the outer ring of 8km as sample No. TK23. There are clearly *two zeolite-rich crater sediments*: (1) Whitish mordenite-rich sediments found at the Inner ring as sample No.15-SSW with high Ni content. This is major sediments of the MKT crater, with the similar Zr dating age of the granitic basement rock. This indicates that source of major crater sediments are the same origin and Zr dating of the Rhyoke granite. In fact, there is no Zr age to indicate large volcanic event of the Seto-Inland Sea. (2) Reddish zeolite-rich sediments: found at the Inner ring as sample No.15-SSR. This is minor sediment of rim of the MKT crater along minor intrusion of andesite, with the younger Zr age. *Two types of glassy rocks* are found in black rocks of samples TK15, 21 and red samples TK15, 22. These glasses have high silica content, and younger Zr ages compared with granitic rock; that is, older black and younger red glasses. This suggests that these glassy breccias are not Miocene volcanic glasses but source originated from granitic rocks. *Four types of suevite-type breccias* with high Y contents, which suggest that it, comes direct from granitic basements. On the inner ring of 4km we found two types of breccia-1 (in sample TK-15 with black and gray breccias of suevite-like rocks), which is similar composition with the granitic rock-1. There is also type rock of breccia-2 (in the sample TK-15 with whitish suevite) which is obtained "intermediate" region of the granite and the glassy rocks. This indicates that there are secondary process between basement granite and glassy rock, which cannot be explained by large volcanic event. On the outer ring of 8km we found two types of breccia-3 (in the sample TK-22 of suevite type rocks), which is close to Mien type rhyolite (i.e. impact glass). Bulk composition of shocked granitic rock of sample TK23 is plotted in the area of the breccia-4. Such various variations of brecciated and granitic rocks are considered to be impact-related process followed by tectonic process of the Japan islands [8,9].

d) Shocked quartz minerals with linear and crossed lamellae: Shocked quartz with clear linear and crossed lamellae is found in the granitic breccia and red breccia in the MKT crater. As quartz mineral has no cleavage or crossed texture in general, such complex lamellar texture is caused by impact shocked process same as in the continental crater (Figs.3,4) [3-9].

e) Fe-Ni rich grains in glassy spherules: These glassy breccias were found to contain small Ni-rich grains (1 to 94% Ni) in glassy spherules, which cannot be found at volcanic and granitic regions so far, as shown in Fig.5.

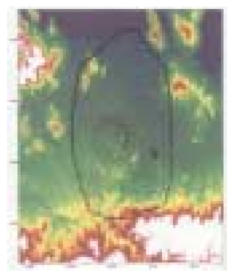
Shocked minerals. A few quartz grains with planar deformation features (PDFs) have been found in clasts in granitic rocks and breccia outcrops within and around the crater. The PDFs in the quartz grains (measured on a U-Stage) occur in the (10$\bar{1}$2), (10$\bar{1}$3) and (10$\bar{1}$1) crystallographic directions indicative of intermediate shock pressures (Figs.3,4). Feldspar grains showing deformation lamellae and diaplectic glass have been found in granitic clasts with glassy clasts and in the matrix of suevite melt breccias outside the gravity anomaly rim (cf.Fig.6) [7-10]. Although quartz with planar and crossed features and possible diaplectic glass are found so far, though further tectonic and volcanic process including buried metamorphism destroys the original Impact texture and minerals in the present MKT crater.

Formation process. The crater MKT impact event occurred in target rocks of Late Cretaceous Rhyoke granite on the proto-Japanese islands located near the continental margin at 15.3 Ma followed by developing an southward opening of the Sea of Japan. The crater was filled and eventually buried during formation of the Japanese Islands to the present location. Original MKT crater structure with double ring structure is broken during the northward formation of the Seto-Inland Sea, followed by small basaltic andesite volcanism around and inside the MKT structure at about 14.2 Ma to break original crater structure [3-9].

Summary. The following is the summary of the present study. 1) New type of impact-related event can be defined at active tectonic regions by using semi-circular structure, bulk composition, shocked materials.2) Bulk XRF compositional data indicate various compositions between granitic basement and glassy breccias. 3) Quartz grains with the PDFs have been found in granitic rocks and breccia outcrops. The PDFs in the quartz mineral grains (measured on a U-Stage) occur in the (10$\bar{1}$2), (10$\bar{1}$3) and (10$\bar{1}$1) crystallographic directions. 3) The MKT impact event occurred in the Late Cretaceous Rhyoke Granite on the proto-Japanese islands located near the continental margin at 15.3 Ma followed by developing a southward opening of the Sea of Japan. The crater was filled and buried during formation of the Japanese Islands. Original MKT crater structure with double ring structure is broken during the northward formation of the Seto-Inland Sea, followed by small basaltic andesite volcanism around and inside the MKT structure at about 14.2 Ma [3-9].

References: [1] Furumoto M., Kono Y. and Miura Y.(1996): Proc. Int. Symp. Obs. Cont. Crust through Drilling, 8, 172-177. [2]Yamada R. and Sato H. (1998): GANKO (in Japanese). 93, 279-290. [3] Miura Y. (1999): Materials Proc.Tech. (Elsevier), 85, 192-193. [4]Miura Y. and M. Kedves (2000): Invest. Earth, Ed. by Miura Y. (Japan), 1, 6-7. 8-13. [5] Miura Y. et al. (2000): LPS XXXI , 2096, 1519, 1645. [6] Miura Y. et al. (2000): Adv.Space Res.(Pergamon), 25, 285-288. [7] Miura Y., Y.Uedo and M.Rampino (2001): LPS XXXII, 1981. [8] Miura Y. (2001): Meteoritics & Planet. Sci., 36, 136-137. [9] Miura Y. and Maeda T. (2001): Proc. 34th ISAS-LPS, 34, 183-186.

Fig.1.Gravity anomaly to show clear inner ring and broken semi- circular structure of Takamatsu MTK crater in Japan [7].



(Left)

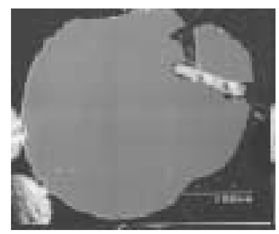
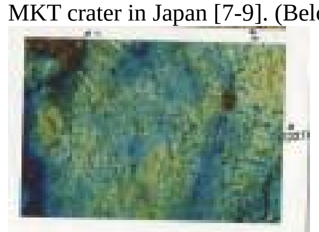


Fig.2. Electron micrograph with the BEI of glassy spherule with zircon mineral [8,9]. (Above right)

Fig.3. Multiple PDFs of shocked quartz in the Takamatsu MKT crater in Japan [7-9]. (Below left)



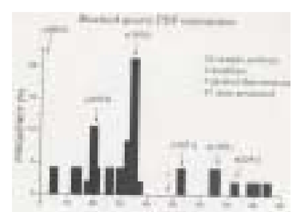


Fig.4. Orientation plot of the PDFs of shocked quartz in the Takamatsu MKT crater in Japan [7-9]. (Above right)

Fig.5. Fe-Ni contents of metallic fragments in breccias of the Takamatsu MTK crater in Japan [3-9]. (Below left)

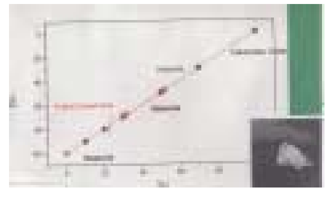


Fig.6. Diagram of SiO2-FeO relation of Takamatsu MKT crater in Japan[8,9]. XRF data. (Above right)