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JAPEX's 60 Years' Experience Exploring Volcanic Reservoirs in Japan*

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Abstract

Japan and New Zealand have many similarities in their geological settings; both are situated on subduction zones of the Pacific Plate, and both countries have a long history of volcanic activity and earthquakes. Japan presently has 110 active volcanoes; during the Miocene period, there was very active submarine volcanic activity in the back- arc basin of the Japan island arc associated with the spreading of the Japan Sea. As a result of the volcanism, many types of volcanic rock were widely deposited in the back- arc basin.

JAPEX (Japan Petroleum Exploration Company Limited) has been mainly exploring the hydrocarbon potential of domestic fields since its establishment over 60 years ago. Back- arc basins are our important targets, and many of our fields have volcanic reservoirs. Whereas worldwide, sandstones and carbonates comprise the main reservoirs, in our domestic fields, volcanic rock is the predominant reservoir (Figure 1). Therefore, the evaluation of volcanic reservoirs is an important task for JAPEX.

Discussion

Volcanic rock erupted underwater consist of many complex facies, and reservoir quality is critically dependent on facies variety. In one of our fields with a rhyolitic volcanic reservoir, rock facies are divided into 3 types; Lava, Breccia, and Hyaloclastite (Figure 2). These volcanic rocks have low original porosity, and secondary porosity such as fractures or dissolution pores play an important role in reservoir quality. Observation and laboratory analysis indicate that diagenetic processes form dissolution pores, which behave as major effective pores in the field. With the contribution from these secondary pores, breccia and lava are of reservoir quality (permeability = 10 md), whereas the reservoir quality of hyaloclastite is poor (permeability < 1 md).

In the actual fields, the distribution of these volcanic facies is complex, and it has therefore been difficult to build this diversity in geology into geologic models using traditional modeling methods. In order to reproduce the architecture of the volcanic reservoirs in the geological model, we have successfully applied the "multiple- point geostatistics" method in the modeling of volcanic reservoirs in some of these oil and gas fields. A training image was created on the basis of geologic concepts, using ideal volcanic objects, their abundance pattern, and their distribution pattern (Figure 3). Then, the training image was applied to hard data (such as actual well log data, core samples), and a facies pattern model was created. The facies pattern was made by storing the neighborhood probabilities of facies types from the training image. The geostatistical models created was used for flow simulation and successfully reproduced the pressure behavior in some fields.

JAPEX is also utilizing its experience in volcanic rock evaluation technology to investigate and develop other field types. Since 1977, JAPEX has conducted surveys of geothermal resources in Japan. Since 2013, JAPEX has applied this technology in geothermal survey wells in volcanic areas. Also, we have provided this technology to Japan CCS Co. Ltd. in the drilling of CCS (Carbon dioxide Capture and Storage; an important technology for reducing CO_2 emissions) injection wells, where testing was conducted to inject CO_2 into resedimented volcaniclastics layers that also work as oil reservoirs in the fields.

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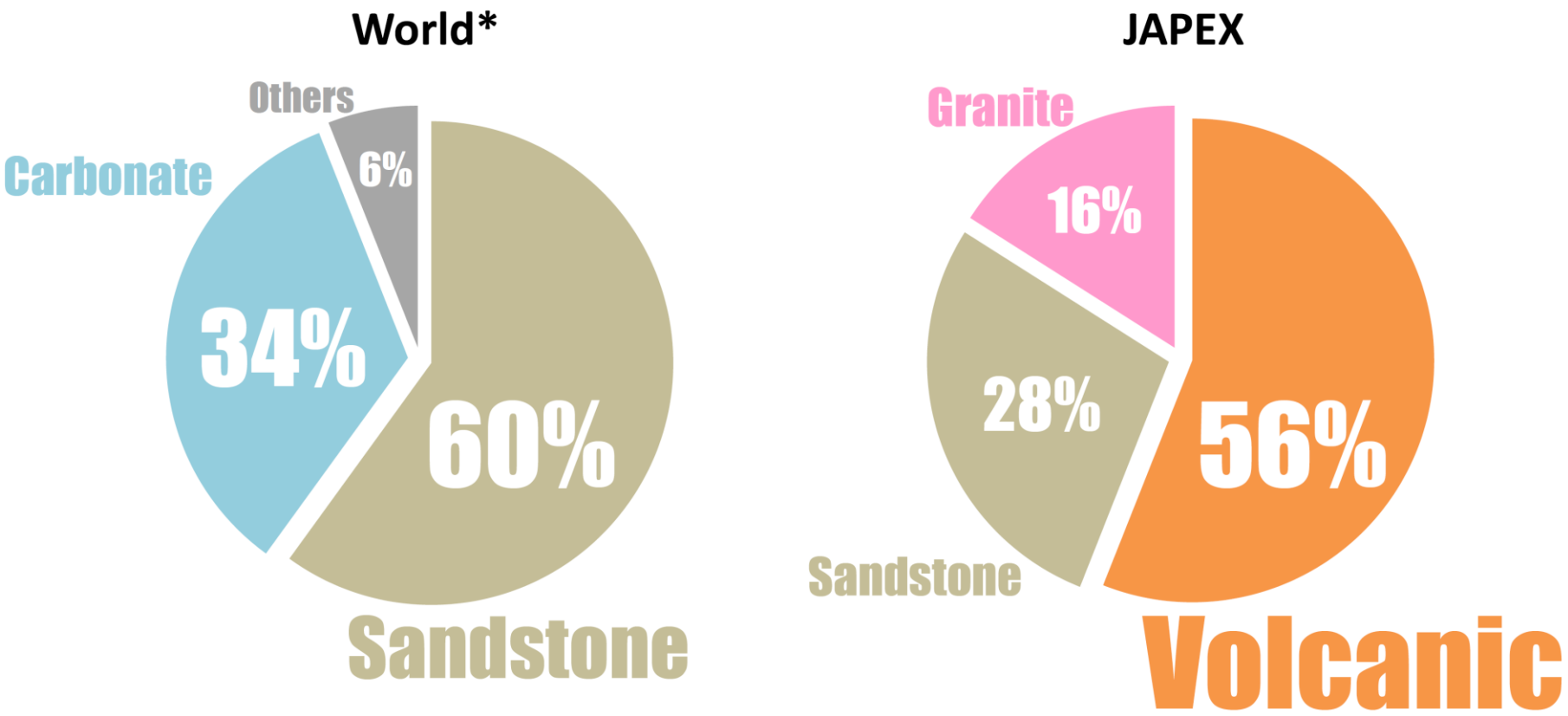

Figure 1. Reservoir types (*data from the Japanese Association for Petroleum Technology).

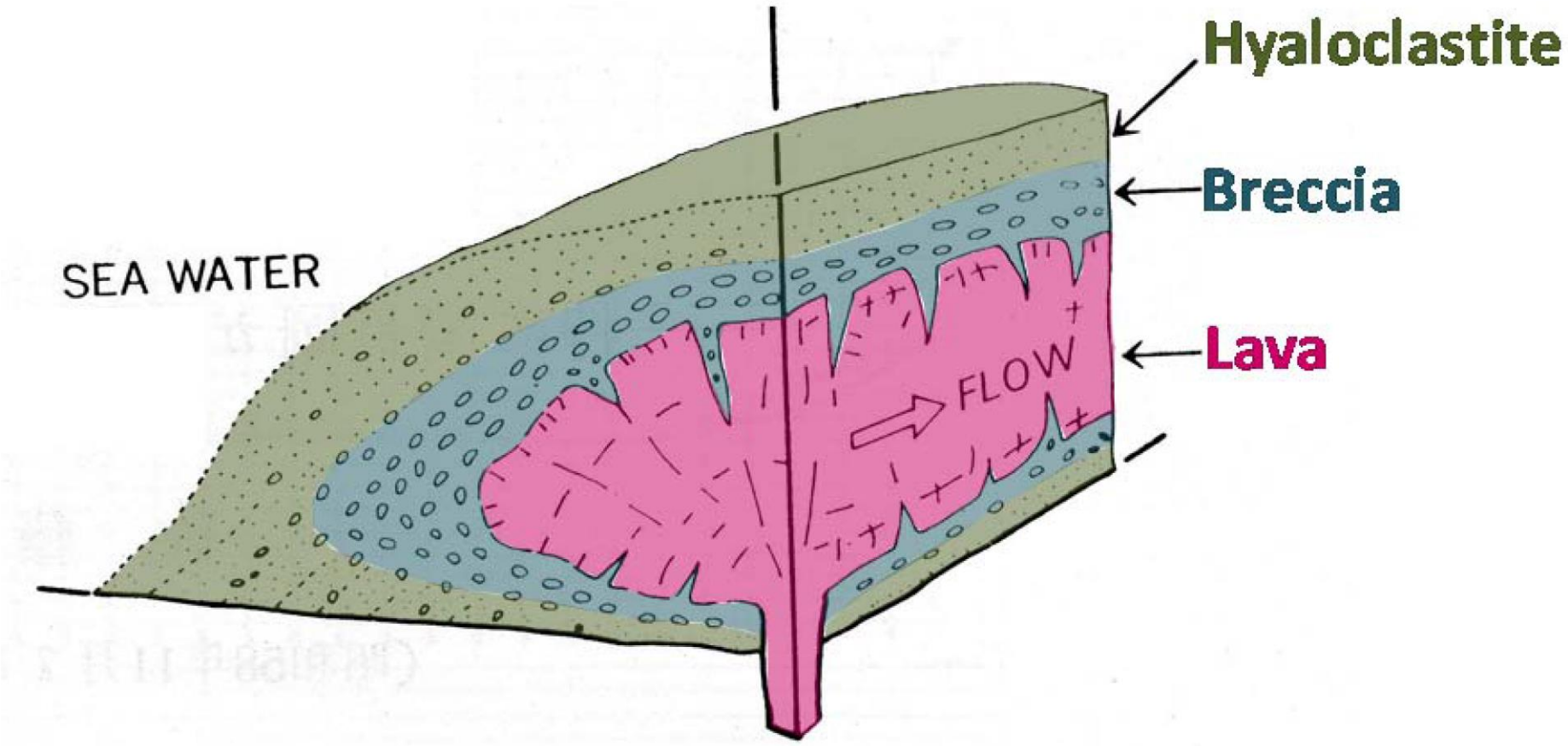

Figure 2. Model of submarine- erupted rhyolitic lava flow (from Sato, 1984).

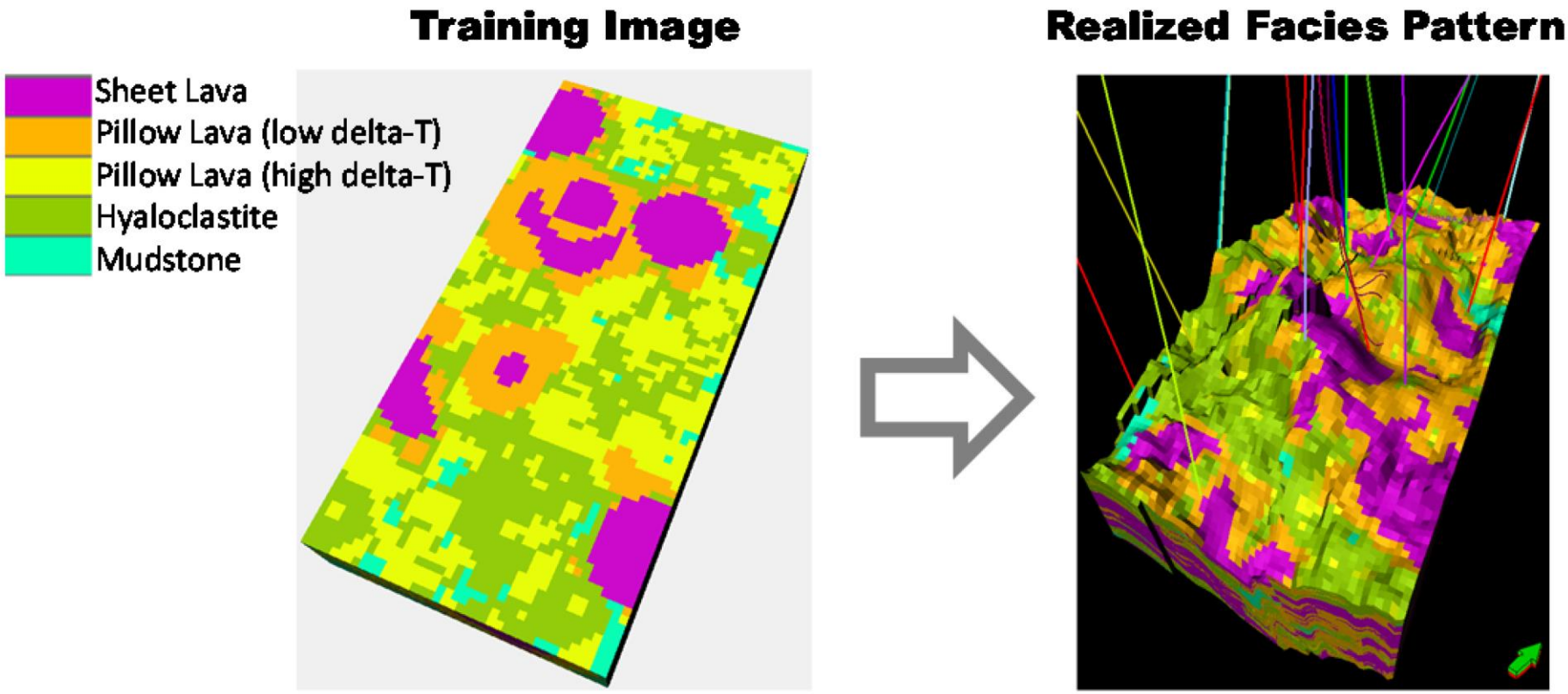

Figure 3. The sample of the training image (left), and realized facies pattern using hard data (right).