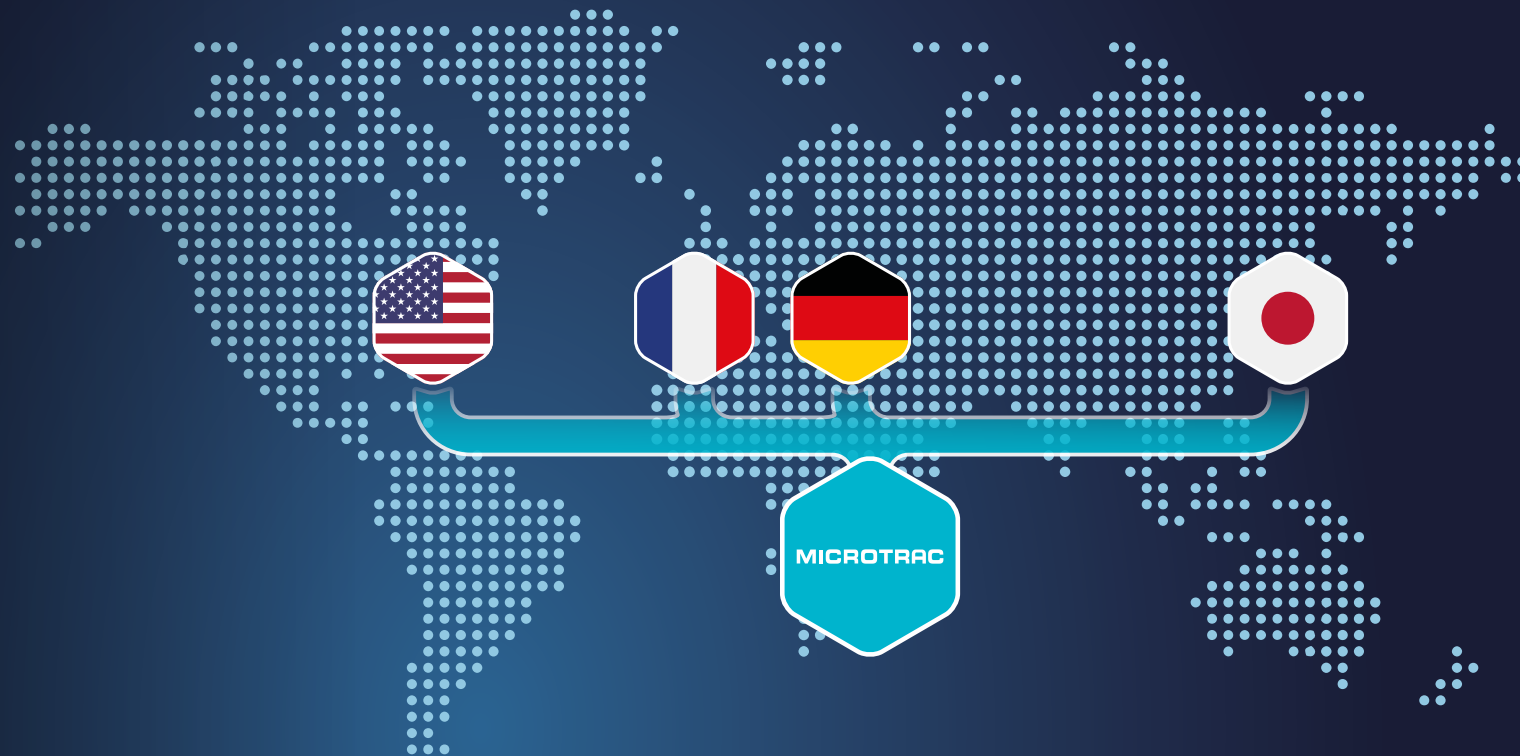




**BELSORP**  
**MAX X**

BET SURFACE AREA AND PORE SIZE DISTRIBUTION ANALYZER

**HIGH-END ADSORPTION. SMALLEST FOOTPRINT.  
UNRIVALED PERFORMANCE.**



## MICROTRAC

# PARTICLE CHARACTERIZATION AT ITS BEST

Microtrac is your preferred partner for the comprehensive characterization of particulate systems. We provide our customers with advanced technologies to obtain consistently reliable results. Innovation and quality are at the core of everything we do.

As part of Verder Scientific, we provide worldwide support through a network of subsidiaries and distributors.



## MICROTRAC

## THREE PILLARS OF EXCELLENCE

## I GAS ADSORPTION MEASUREMENT

The BELSORP and BELPORA analyzers are used for the determination of gas and vapor adsorption amounts, as well as BET surface area and pore size distribution. The measuring instruments use gas adsorption technology to analyze both porous and non-porous powder materials. These products are used all over the world in Research and Development, Quality Control, and Quality Assurance. The competence centers for these product lines are located in Osaka (Japan) and Haan (Germany).

## I PARTICLE SIZE &amp; SHAPE ANALYSIS

Dynamic Image Analysis (DIA) and Laser Diffraction (LD) technologies are used in our optical particle analyzers for the physical characterization of particles. Microtrac is the only worldwide

supplier of dynamic image analysis, static image analysis, laser diffraction, and sieve analysis equipment.

DIA is used to determine size distributions and shape parameters quickly with excellent accuracy and reproducibility over a wide measuring range. Microtrac's renowned CAMSIZER system was introduced over 20 years ago and has pushed technological innovation ever since. These instruments are developed and built in our production site in Haan, Germany.

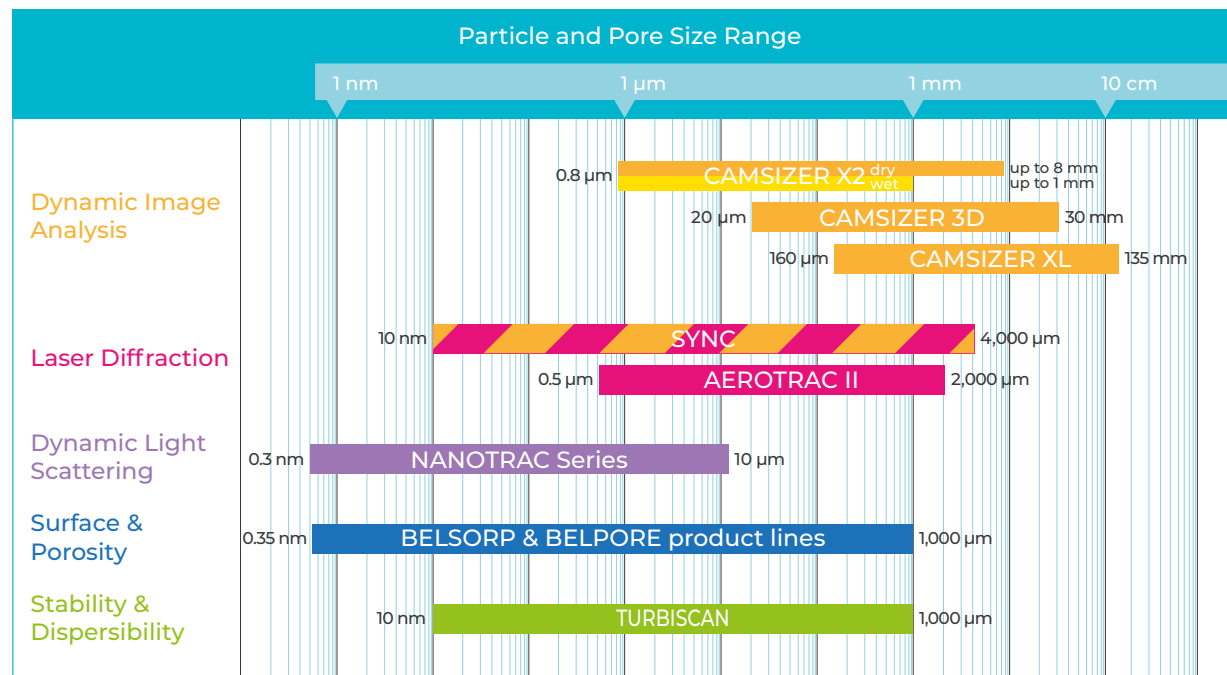
In 2024, Microtrac celebrates 50 years of Laser Diffraction as a global leader. We are pioneers in this field, with our SYNC range. By continuously improving the instrument technology, we offer customers a robust portfolio of laser diffraction instru-

ments that are ideal for particle sizing and characterization. The development and production site for this product line is located in Pennsylvania, USA.

## I STABILITY &amp; DISPERSIBILITY ANALYSIS

Our Stability Analyzers use Dynamic Light Scattering (DLS), Static Multiple Light Scattering (SMLS), and Zeta Potential (ZP) to measure the stability and dispersibility of all your formulas. The latest addition to the Microtrac portfolio is the TURBISCAN range.

With TURBISCAN, Microtrac offers the world leading technology for Shelf-Life and Dispersibility analysis of liquid dispersions and formulations. The TURBISCAN range is developed and built in our factory in Toulouse, France.



## BELSORP MAX X

# HIGHLY ACCURATE GAS & VAPOR ADSORPTION

- | Smallest footprint: more compact design, lower weight
- | Highly reproducible BET specific surface area and pore size distribution evaluation
- | Highest throughput with simultaneous measurement of up to 4 samples
- | Advanced Free Space Measurement: AFSM™ and AFSM2™ (Helium-free)
- | Low specific surface area evaluation by Kr adsorption at 77.4 K
- | Evaluation of hydrophilic and hydrophobic material
- | Adsorption rate measurement for various gases and vapors
- | Supports a wide range of gas / vapor adsorbates and measurement conditions
- | Chemisorption option
- | Measures various materials such as molded bodies, pellets, and fine powders



The BELSORP MAX X is a versatile instrument that measures specific surface area, pore size distribution, vapor adsorption, and chemisorption. The instrument allows for comprehensive surface characterization, such as BET surface area and micropore analysis, by measuring the adsorption isotherms from extremely low pressures, organic vapor sorption or hydrophilicity / hydrophobicity characterization through water vapor adsorption.

These capabilities are accomplished by the proprietary technical advantages of heated manifold blocks (50°C, opt. version BELSORP MAX HT 80°C) for a constant ambient temperature, heated air bath, and electropolished manifold lines to avoid surface wetting and corrosion. Furthermore, the BELSORP MAX X features pneumatic valves to minimize leakages or outgassing when working with high vacuum.

The BELSORP MAX X not only supports a wide range of gas and vapor adsorbates, but various measurement conditions as well. In addition, the special version BELSORP MAX X HP can measure isotherms up to 0.9 MPa



### BELSORP MAX X Features

- ▶ **Specific surface area range:**
  - | 0.01 m<sup>2</sup>/g or more (N<sub>2</sub>)
  - | 0.0005 m<sup>2</sup>/g or more (Kr)
- ▶ **Pore size distribution range:**
  - | 0.35 to 500 nm
- ▶ **Highly accurate vapor adsorption measurement under strict temperature control**
- ▶ **Advanced GCMC / NLDFT method offers higher resolution & more precise PSD analysis**
- ▶ **IoT: Measurement status & results remotely via e-mail system**

## BELSORP MAX X

# BELCONTROL OPERATION SOFTWARE

The software has given the highest priority to simplify the operation and has been equipped with many functions to increase the labor productivity. Since the BELSORP instruments offer many features and possibilities, it gets more and more important to simplify the use. Our software will guide you step-by-step for the implementation of several procedures e.g. execution of measurements, replacement of gas cylinder, purging of the manifold and degassing of liquid adsorbent. This user-friendly feature is making the instrument accessible even for non-experienced users.

For the isotherm measurement conditions two possibilities are offered depending on the level of user-experience.

Firstly, the 'automated setting' enables an easy operation by entering the sample information, selecting pretreatment conditions (skippable if externally done) and measurement points/range. Therefore, it is ideal for measurement of unknown samples or unexperienced users. If a prior measurement with comparable sorption behavior is available, the GDO function can be used to reduce the measurement time.

Secondly, the 'advanced setting' offers detailed configuration possibilities for control of dosing amounts and equilibrium criteria to optimize measurement conditions manually. The e-mail notification automatically sends the measurement status and results as an e-mail. With this function easy and reliable monitoring will be given. Our instruments are equipped with a diagnostic service tool, the so-called System Check. It enables functionality proof of the main parts and the equipment status. The System Check result is saved as a report, summarizing the leakage rates, functionality of single parts.





Control up to 5 units / 20 measurement ports with a single PC

### High Precision Mode

For high-precision measurements the amount of free space change in the sample section is simultaneously measured at the reference port (AFSM™). The other remaining ports are used for measuring the adsorption / desorption isotherms, while the saturated vapor pressure is constantly monitored with a dedicated port.

Resolution: 0.01 m<sup>2</sup>

Reproducibility:

Total surface area 1 m<sup>2</sup> → ± 1.2%\*

Total surface area 10 m<sup>2</sup> → ± 0.4%

### Multi-Sample Mode

This mode allows for measuring adsorption and desorption isotherms with up to four samples, while the saturation vapor pressure is constantly measured at the dedicated port. The free space change can be automatically calculated from the prior saved free space file (*dvd*).

Resolution: 0.01 m<sup>2</sup>

Reproducibility:

Total surface area 10 m<sup>2</sup> → ± 0.5%

### Software Features

- ▶ Microtrac's measurement operation software features a uniform user experience and can be used with BELSORP MINI X, MAX G, and MAX X
- ▶ The software offers automated and manual settings so that optimization can be made based on user experience
- ▶ Three sub modes are available:
  - I High-precision mode for R&D
  - I Multi-sample mode for high throughput
  - I Quick BET mode for QC

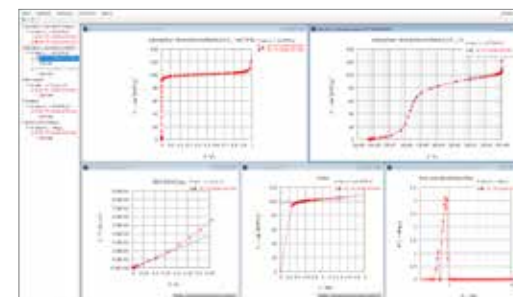
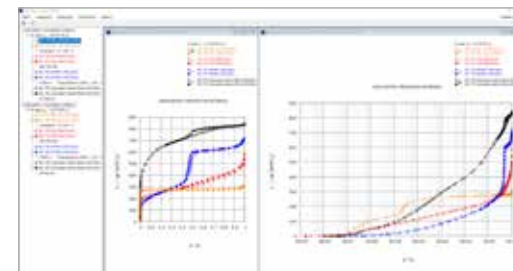
### Quick BET Mode

The quick BET mode can be used to maximize the sample throughput. In this mode it is possible to measure three BET adsorption points for four samples in approx. 15 minutes.

\* The total surface area (m<sup>2</sup>) is the product of both the specific surface area (m<sup>2</sup>/g) and the sample mass.

## BELSORP MAX X

# BELMASTER EVALUATION SOFTWARE



### Software Features

- ▶ Analysis data and results can be saved by Drag & Drop (MS Excel format)
- ▶ Easy change of chart overwriting, X-Y axis scaling, unit conversion, and more
- ▶ Result window can be saved for further analysis after a computer restart
- ▶ Routine analysis setting function (useful for repeated analyses)
- ▶ Customized data can be registered as standard reference isotherms in pore profile analyses, t-plot and  $\alpha_s$
- ▶ Improved visibility for different analyses through individual color setting for custom data

The evaluation software BELMASTER offers a wide range of both basic and advanced analytical theories which have been developed over many years of experience and provides the widest characterization of the samples:

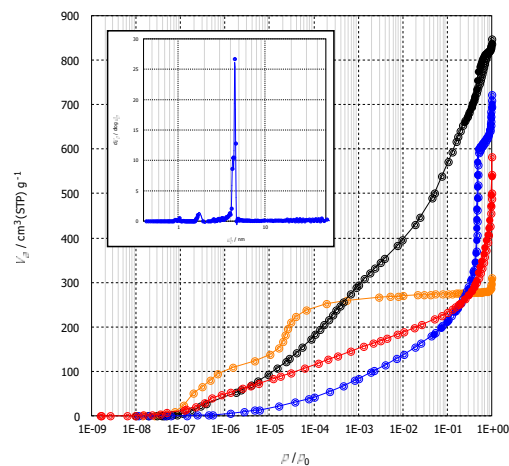
- | Adsorption-desorption isotherm / PCT curve
- | BET Specific Surface Area, incl. ISO9277 / Rouquerol plot for Type I isotherms
- | Langmuir & Freundlich specific surface area
- | INNES, BJH DH & CI method (mesopores)
- | HK, SF & CY method (micropore distribution, only for BELSORP MAX series)

- | t-plot method (micro to mesopore analysis)
- |  $\alpha_s$  plot method (micro to mesopore analysis)
- | MP method (micropore distribution)
- | Dubinin-Astakhov & Dubinin-Radushkevich method (micropore volume)
- | Isosteric heat of adsorption (for MAX series)
- | Differential adsorption isotherm
- | Fractal dimension
- | Molecular Probe Method (ultra micropore)
- | Adsorption rate analysis & Metal dispersion
- | BELSim™: NLDFT / GCMC (ISO15901-2) for micro- to- macropore distribution

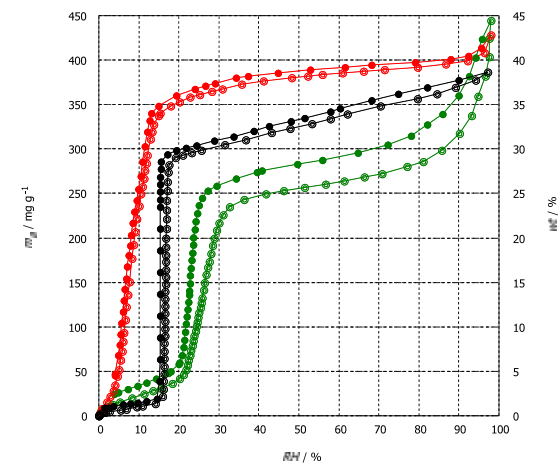


## MEASUREMENT RESULTS

## BELSORP MAX X

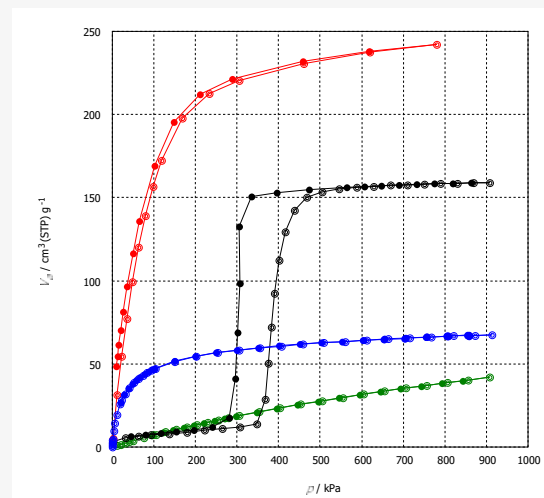


Nitrogen sorption measurements of micro-/mesoporous materials: metal-organic framework MIL-160 (orange), Pd-Carbon (red), activated carbon fibre (black) and MCM-41 (blue) at 77.4 K. Top, left: Exemplary GCMC pore size distributions of MCM-41 (blue) based on nitrogen adsorption isotherms at 77.4 K.

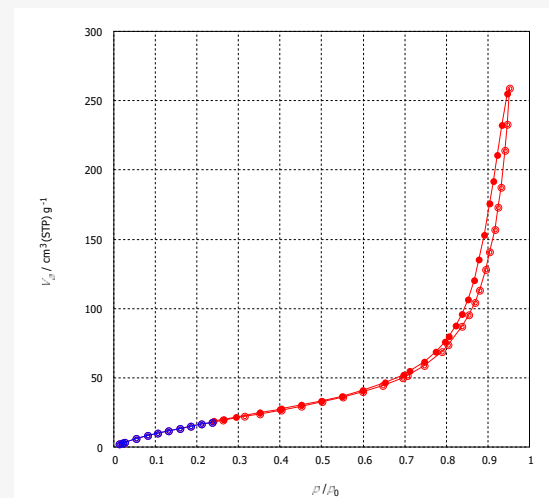


Water sorption measurements of the three metal-organic frameworks (MOFs): Aluminum-fumarate (green), MIL-160 (red) and CAU-10H (black) at 25 °C.

Microtrac provides evaluation methods which cover a wide range of pore sizes and various adsorbates, such as  $N_2$  (77.4 K), Ar (87.3 K), and  $CO_2$  (298 K). It uses NLDFT / GCMC kernels of slit, cylinder, and cage pore models with carbon and metal oxide surface atoms, resulting in the most appropriate description of porous materials. Our BELMASTER software (Ver. 7) allows for the easy comparison between experimental and simulated isotherms, with the simulated isotherm serving as a basis for the PSD calculation. The similarity between them is an indicator for the correct PSD calculation.



High pressure gas sorption isotherms of ZSM-5  $CO_2$  at 20 °C (blue), Activated Carbon  $N_2$  at 25 °C (green), LaNi5  $H_2$  at 25 °C (black) and Kuractive  $NH_3$  at 25 °C (red) on BELSORP MAX X HP model.



High temperature water sorption isotherms of Aerosil at 70 °C on BELSORP MAX X (blue) and BELSORP MAX X HT model (red) incl. measurable relative pressure ranges (table).

## BELSORP MAX X

# FURTHER OPTIONS & ACCESSORIES



### STANDARD CONSUMABLE GOODS

| Sample cells, filler rods, filters, O-rings, caps & weighing platforms, NSD capsules, liquid bottles, various sizes of sample cells, quick seals, and much more.



### GAS SELECTORS

| Up to 12 gases can be mounted with external gas selectors to accommodate different types of adsorbates.



### HEATER & CONTROLLER

| Pretreatment of the sample from 50°C up to 550°C.



### WATER BATH

| Water bath for measurement temperature ranging from -10°C to 80°C. A refrigerated / heated circulator is required for usage.




### ACCESSORIES FOR VAPOR SORPTION

| Our accessories for vapor sorption include a detachable air bath, glass vessel for liquids, a reference sample for vapor sorption, and a Dewar for the degassing of liquids.

## TECHNICAL DETAILS


# SPECIFICATIONS AT A GLANCE

System	BELSORP MAX X	BELSORP MAX X HP	BELSORP MAX X HT
Measurement principle	Volumetric / manometric method + AFSM™ (Advanced Free Space Measurement)		
Adsorption gas	N <sub>2</sub> , Ar, Kr, CO <sub>2</sub> , H <sub>2</sub> , O <sub>2</sub> , CH <sub>4</sub> , NH <sub>3</sub> , NO, CO, butane, and various other non-corrosive gases		
Adsorption vapor	H <sub>2</sub> O, MeOH, EtOH, C <sub>6</sub> H <sub>6</sub> , CCl <sub>4</sub> , hexane, and various other (non-)corrosive vapors		
Number of measurements (high accuracy mode)	Max. 4 ports simultaneously (3)	Max. 3 ports simultaneously (2), 1 port for high pressure	Max. 4 ports simultaneously (3)
Specific surface area	~0.01 m <sup>2</sup> /g (N <sub>2</sub> ), ~0.0005m <sup>2</sup> /g (Kr) (depending on sample density)		
Pore size distribution (ø)	0.35~500 nm (from ~0.25 nm when CO <sub>2</sub> is used)		
Low pressure isotherm	P/P <sub>0</sub> = ~10 <sup>-9</sup> (N <sub>2</sub> @ 77K, Ar @ 87K)		
Vapor adsorption	P/P <sub>0</sub> = ~0.95 @ 40°C		P/P <sub>0</sub> = ~0.95 @ 70°C
High pressure	■	10 Pa ~ 900 kPa	■
1 MPa (7500 Torr)	■	1	■
133 kPa (1000 Torr)	6	5	6
1.33 kPa (10 Torr)	4 (max.)	3	4
0.0133 kPa (0.1 Torr)	3 (max.)	2	■
Thermostatic air oven	50°C		80°C
Gas ports	3 ports* (optional 6, 9 or 12 ports max.)	3 ports* (optional 6, 9 or 12 ports max.)	
CE certificate			

\* Corrosion-resistant

07/2023 Subject to technical modifications and errors

System	Pore size distribution	Micropore	Mesopore	Macropore	Isotherm	Single point BET	Multi point BET	Vapor adsorption	Chemisorption (static volumetric)	True density
BELSORP MAX X	+	+	+	+	+	+	+	+	+	+

 suitable  
  suitable to a limited extent  
  not suitable

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# VERDER

scientific

VERDER SCIENTIFIC

# ENABLING PROGRESS.

Under the roof of VERDER SCIENTIFIC we support thousands of customers worldwide in realizing the ambition we share.

As their technology partner behind the scenes, we deliver the solutions they need to make progress and to improve the everyday lives of countless people. Together, we make the world a healthier, safer and more sustainable place.

