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40 Years of Women in the Geothermal Sector: 1980-2020

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ABSTRACT

Over the past 40 years, women's participation in the geothermal sector in the USA has increased. In 1980, women authored 7.5% of the papers given at the annual meeting of the Geothermal Resources Council (GRC) (now known as Geothermal Rising). By 2019, the proportion of female authors was 16%. Similarly, the proportion of female authors for the World Geothermal Congress (WGC) increased from 8% in 1995 to ~22% in 2020 and has doubled at the Stanford Geothermal Workshop over the last 40 years. Women represented 11% of the GRC membership in 2010, and by 2019 this number had increased to 16%. At this rate of increase, and assuming all else remains equal, the number of women in the geothermal sector will achieve parity with men near the year 2100. Statistics from professional societies of other resource related industries (e.g., SPE, SEG, AAPG) show similar increases in women's participation in these industries over the same time period and are also a long way from achieving parity with men.

Women in the geothermal sector work in various disciplines including engineering, geoscience, law, economics, business, marketing, and administration. Preliminary data obtained from the geothermal industry in the USA indicates that employment in some STEM-related jobs (e.g., power plant operation and maintenance, drilling engineering, reservoir engineering) are disproportionately lower in geothermal compared to other disciplines (finance, business, administration etc.). The reasons for the proportionally-lower representation of women in technical/STEM fields are numerous and complex. However, organizations such as WING (Women in Geothermal) are attempting to increase the proportion of women in the geothermal sector through education, mentorship programs, raising awareness of the challenges women face, and through encouraging cultural changes in the workplace/sector. In this paper, we present a review of women's participation in the US geothermal sector over the last 40 years, as well as how these statistics compare with other extractive industries (i.e., oil and gas, and mining) in the USA.

1. INTRODUCTION

Numerous studies have been performed to determine the number of women in STEM and science career fields. They demonstrate the need for more participation of women in science specific fields. However, few of those studies are directed at resource industries, which require specialized training and working in what were traditionally men's fields. It is readily recognizable that women are minorities in parts of the geothermal sector, however quantitative data on gender diversity are rarely available. In order to design and implement initiatives to improve female participation in geothermal, it is important to know the current status of the gender balance within the sector.

WING-USA, along with the country WING teams and the Global WING team, has worked hard over past five years to spread awareness within the geothermal sector about representation of women in this STEM career field. We are proud of the strides that WING has made in the past five years but understand and accept there is much work still to be done. The goal of this study was to collate and present information about the involvement of women in the geothermal sector over the last 40 years, using information such as the proportion of membership and authorship as proxies for female participation more broadly. This data compilation raises visibility of the gender gap and provides a reference frame for past and current trajectories of the gender balance in the geothermal sector. These data serve as a benchmark from which we can advocate for future growth in female participation and contribution.

2. METHODS

2.1 Data collection approaches

The data presented in this study were compiled from a number of publicly-available sources, and using information-gathering approaches (such as surveys). We reviewed the membership rosters (Geothermal Resources Council (GRC), now known as Geothermal Rising) and paper authorship (GRC, Stanford, World Geothermal Congress (WGC)) for geothermal-specific conferences and workshops to extract participation by gender. Authors' genders were determined by several means including categorizing via knowledge of gender-specific names, personal knowledge, social media websites (primarily photos from LinkedIn, ResearchGate, Facebook, etc.), gender specification in media (he, she, Mr., Ms., etc.), and academic and company websites.

All statistics were compiled as percentage by gender (women, men, or unknown) of the total number of members, authors, or presenters. The percent unknown is considered to the be margin of error for each dataset. For example, if 100 authors were analyzed, and 4% were of unknown gender, then the uncertainty in percentage of women could be a maximum of ~4% greater than we estimated. In total, 35 conference proceedings were reviewed, and the average number of unknowns was 3.9%.

In addition to this 'passive' information gathering approach, a survey was distributed to key industry and consulting firms that are operating in the USA to evaluate the types of roles that women are working in for the geothermal sector.

3. RESULTS: WOMEN IN GEOTHERMAL BY THE NUMBERS

3.1 Female membership in geothermal societies

Geothermal organizations do not publish the percentage of their membership, or the gender of their members, and rosters of membership are not readily available in part due to recent legislation on privacy. For this study, we reviewed the membership of the GRC – an organization that was established in the USA in 1971 to support the geothermal sector through education, research and outreach activities. Membership rosters from 1985, 1990, 1993-1999, 2008-2010, and 2017-2019 were reviewed to extract the gender demographics from print or online versions.

GRC members include people working in various occupations including as geologists, geochemists, geophysicists, reservoir engineers, mathematicians, computer scientists, policy makers, business developers, power plant engineers, drilling experts, and students. The data illustrate a trend of increasing proportion of female members over the time interval surveyed, from less than 6% in the mid-1980's, to over 16% in 2019 (Figure 1). Interestingly, during a time of large influx of funding into the geothermal sector (roughly 2008-2010), there was also an increase in female participation as suggested by the GRC membership data. The decline of female membership in the last couple of years, based on these data, is what WING-USA is working to reverse.

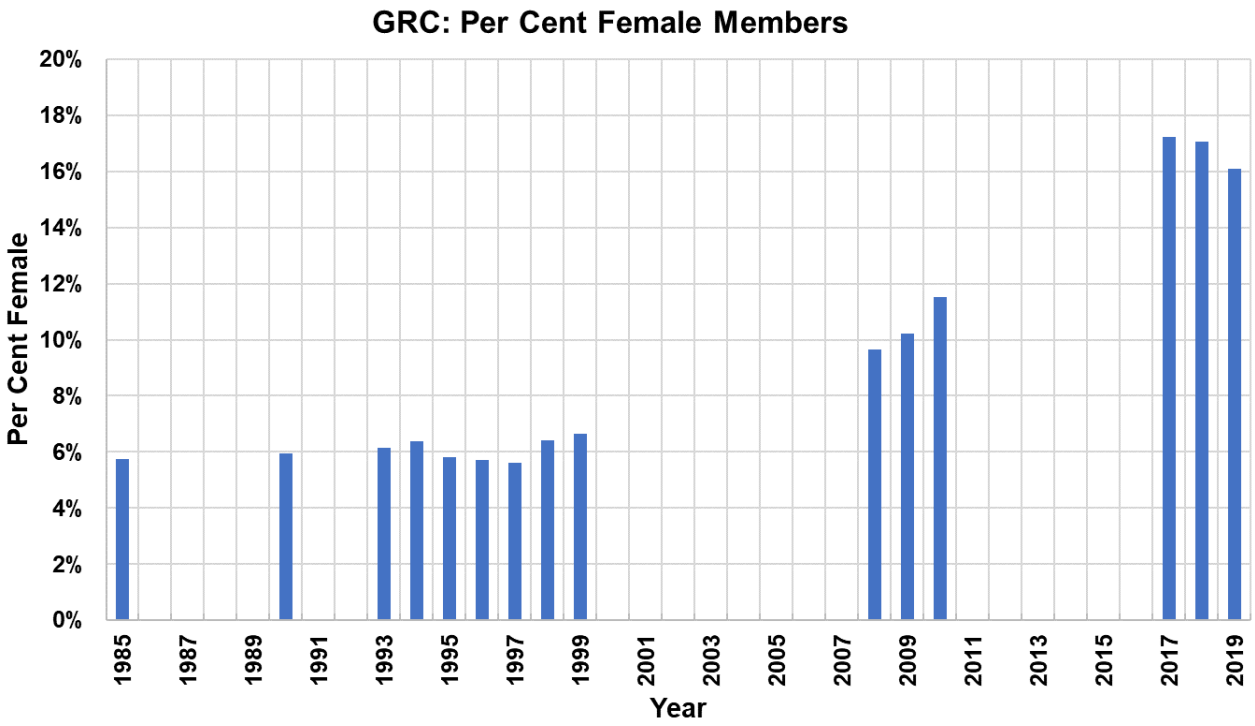

Figure 1: Proportion female GRC membership from 1985 – 2019.

3.2 Women serving on geothermal Boards of Directors

Data were collated for the Geothermal Resources Council and International Geothermal Association Boards of Directors in terms of female board members appointed between 1989 – 2019. Both organizations display a steady increase from 1989, though both still maintain less than 30% female board membership (GRC data for 2019) (Figure 2). The International Geothermal Association has recently adopted a gender diversity policy. The 2020-2023 board, elected in 2019, is comprised of 60% female members.

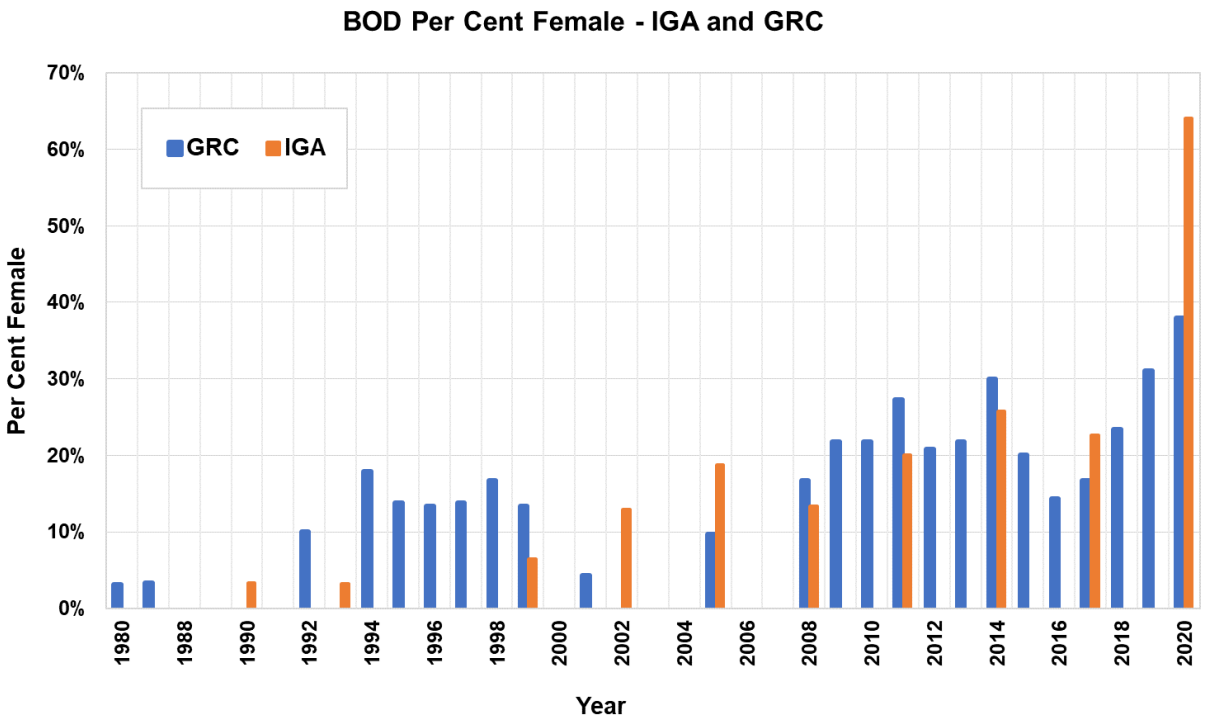

Figure 2: Proportion female members on the Board of Directors of the GRC and IGA.

3.3 Women participating in the Geothermal Training Program of the United Nations University (UNU-GTP)

The United Nations University Geothermal Training Program (now GRÓ GTP under UNESCO) is a six-month post-graduate education primarily for students from developing countries that have geothermal resource sectors. From 1979-2019, 731 scientists and engineers from 61 countries have completed the annual training. The growth in the number of students, and by gender, over 40 sessions is shown in Figure 3. Participation by women has climbed steadily, reaching near or at 45% women in the past few years (Figure 4), which is a promising trend. The program has emphasized gender equality and diversity aspects in its strategic plan for 2016-2019.

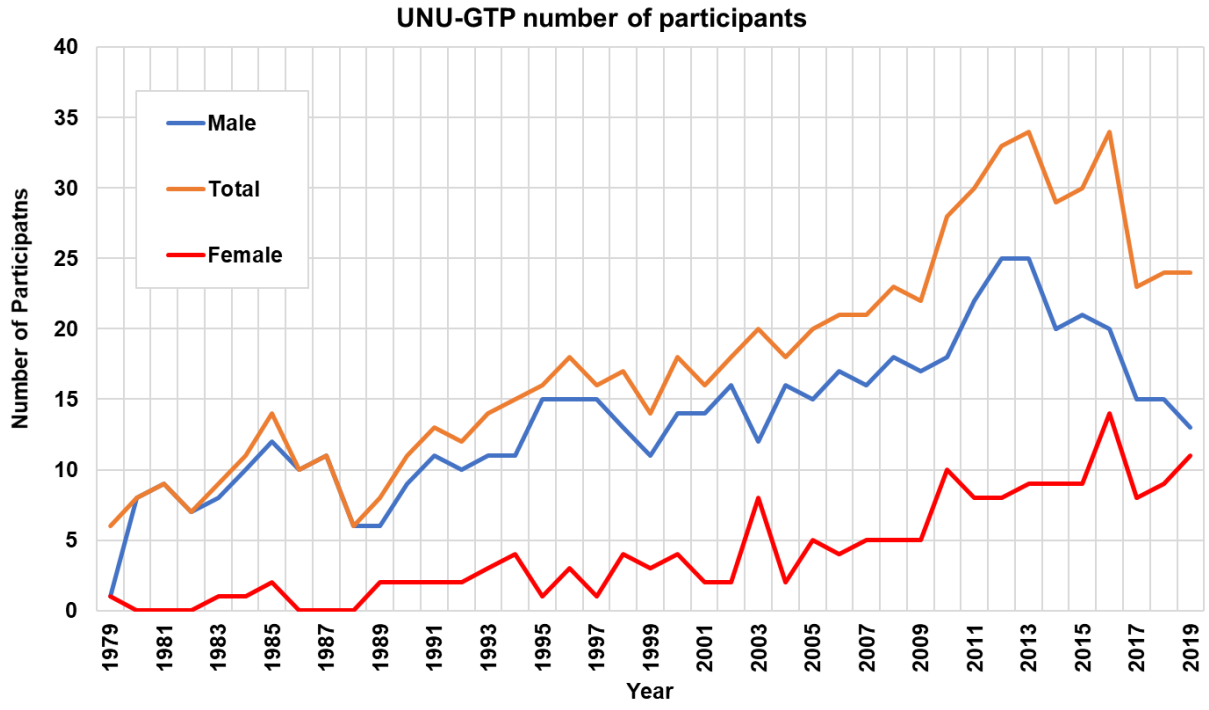

Figure 3: Gender demographics for participants in the United Nations University Geothermal Training Program (UNU-GTP) between 1979 and 2019.

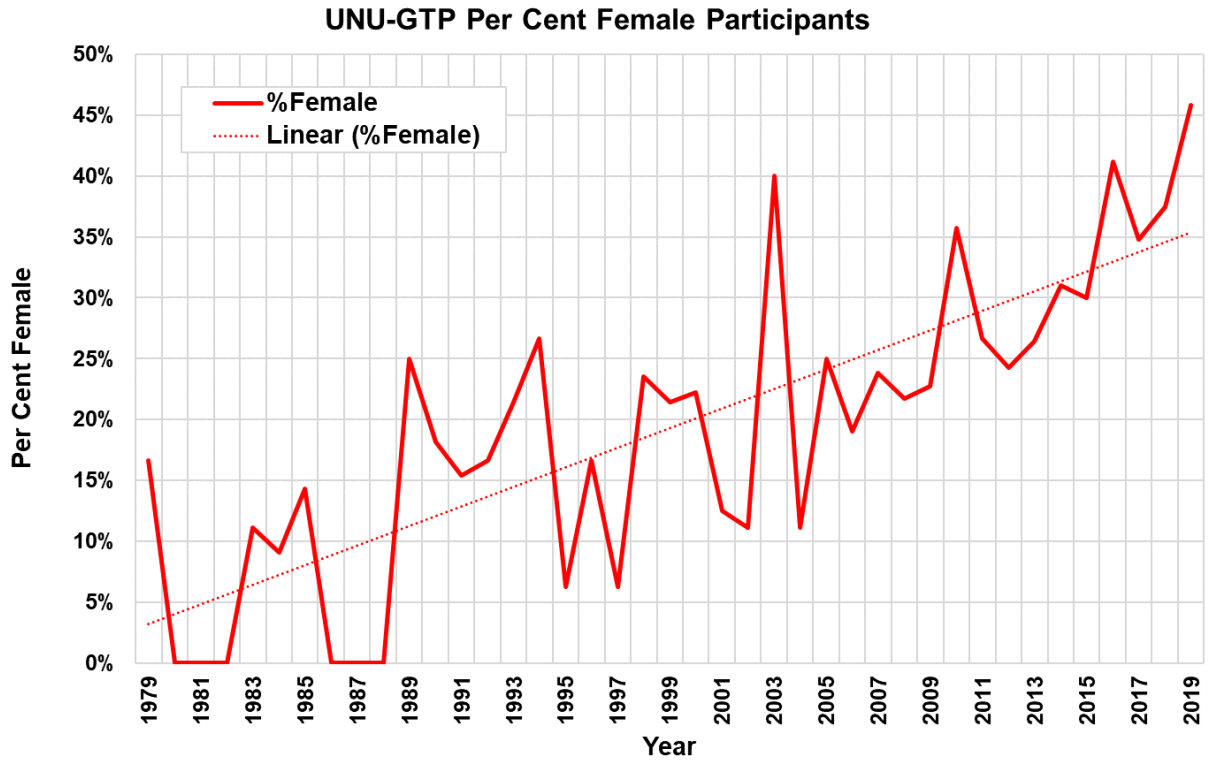

Figure 4: Percentage female participants in the United Nations University Geothermal Training Program (UNU-GTP), illustrating the increasing trend with time.

3.4 Female authors at geothermal conferences

Paper authors were reviewed for 37 conferences from three different organizations: GRC, Stanford Workshop on Geothermal Reservoir Engineering, and the World Geothermal Conference (WGC). The WGC first convened in 1995, with meetings every five years during the 2nd quarter of the year. The GRC annual meeting has been held yearly, normally in the 3rd or 4th quarter of the year, since 1977. The Stanford Geothermal Workshop (SGW) has been held annually since 1975, with meetings usually in the 1st quarter. All paper authors were included in the tally of numbers (including duplicates) in order to represent the total number of authors by gender. A comparison was made between including all authors and removing duplicates. This made a difference in the proportion of authors by gender of less than 1%. The data illustrate a gradual increase in female authorship at these three major conferences from 1980 (Figure 5). The highest proportion of female authors is expected to occur at this conference (2020 WGC, now to be held in 2021), with over 22% female authorship.

Comparison of female authorship at the three conferences (GRC, WGC, SGW) with female members of GRC, and female presenters illustrates the consistent growth in participation of women in the sector (Figure 6). The chart illustrates the growth in female participation over the past 40 years, as well as the greater proportion of female authors and presenters compared to female membership in the GRC. This increase, especially in the last 15+ years, is encouraging.

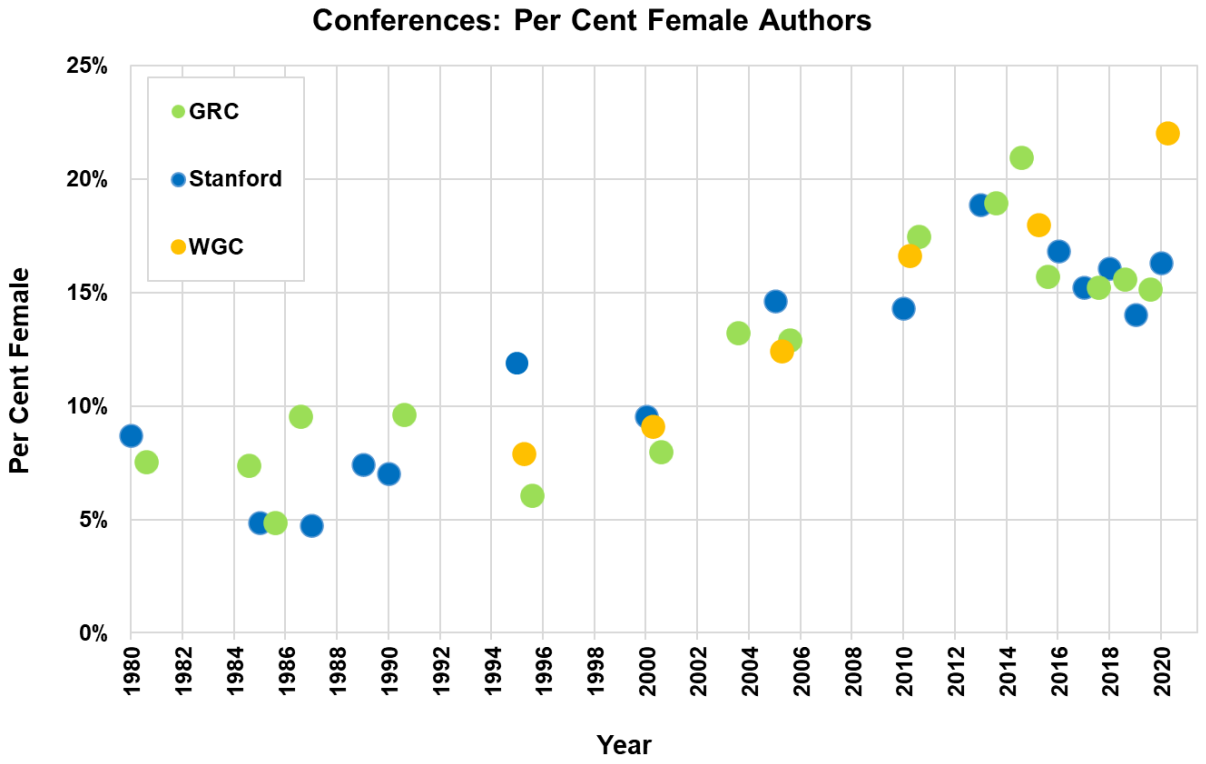

Figure 2: Female authorship at the GRC, Stanford and WGC geothermal conferences between 1980 and 2020.

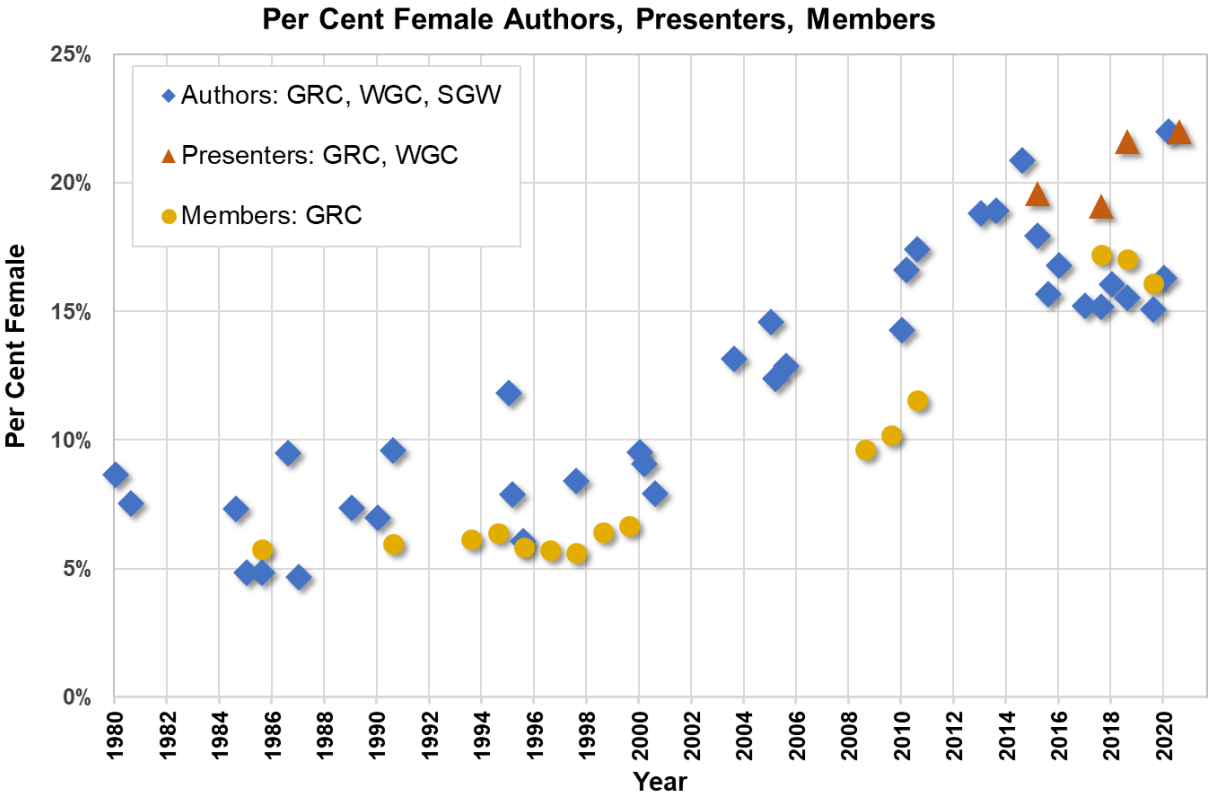

Figure 3: Comparison of the proportion female members, authors, and presenters for geothermal conferences (GRC, WGC, SGW).

3.5 Job types for women in the geothermal sector, USA

In June-July 2019, WING-USA circulated a survey to geothermal companies and consultancies in the western USA, to provide more insight into the types of roles in which women are employed. The organizations that responded included the following: AltaRock Energy, Calpine, Cyrq Energy, Geologica Geothermal Resource Solutions, Geothermal Resource Group, GeothermEx, ThermoChem, and Ormat Nevada, Inc. For the survey, we asked that only US-based employees were included in the totals, and that if an employee

had more than one role, that the dominant or more senior role was counted. In total, these organizations collectively had 945 employees working in geothermal-dominated roles. In this, 140 were women, comprising 15% of workers. Evaluating the trends more closely, we observe that proportionally more women contribute to legal, finance, business-development, and administration with over 30% of these roles being comprised of women. Roles such as drilling-related jobs, power plant and surface operations and maintenance, permitting, information technology (IT), and database management have relatively low proportions of female workers (less than 10%) (Figure 7). In terms of total numbers of women, almost half of the female employees in this survey work in administration (74 women), followed by finance (17 women), geoscience focused roles (13), and then technician-type roles (10 women) (Figure 7 and 8).

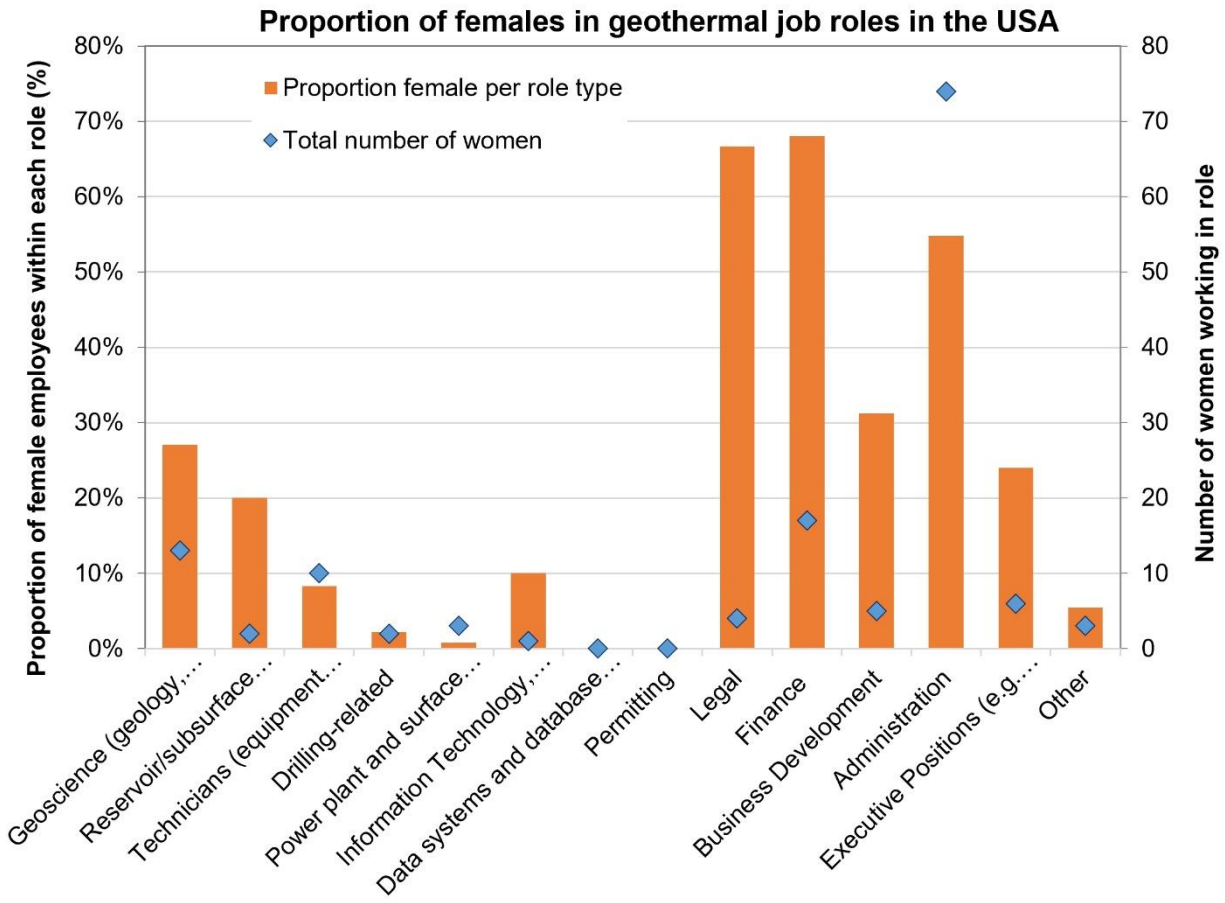

Figure 7: The proportion of women within each role type within the US organizations surveyed in July 2019.

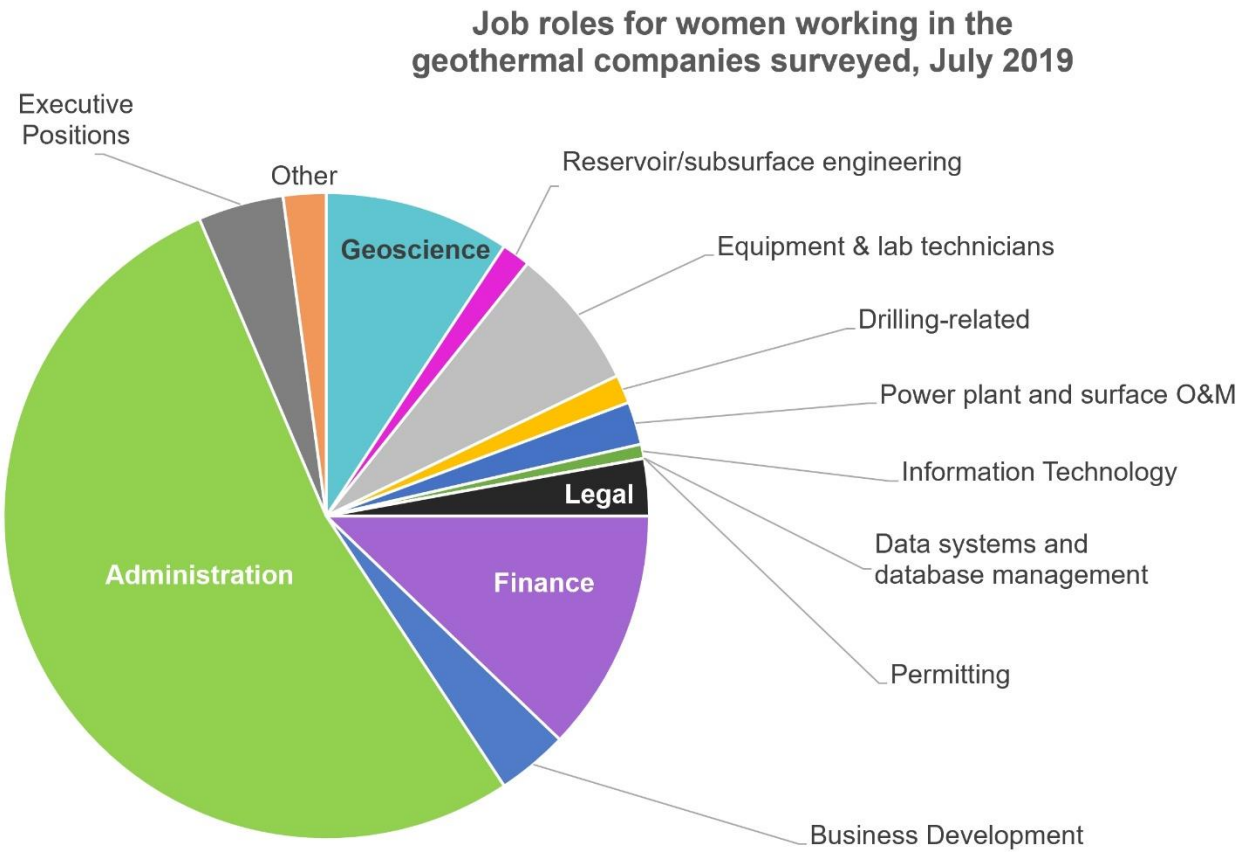

Figure 8: Proportion of total women working in each role type in US geothermal companies.

4. FEMALE PARTICIPATION IN OTHER GEOSCIENCE PROFESSIONAL SOCIETIES AND RESOURCE INDUSTRIES

4.1 Female membership in professional geoscience societies

The number of female scientists in the geothermal industry are compared to statistics available for females in other geoscience societies: SEG (Society of Exploration Geophysicists, SPE (Society of Petroleum Engineers), AGU (American Geophysical Union), AAPG (American Association of Petroleum Geologists), EAGE (European Association of Geoscientists and Engineers) (Figure 9). It should be noted that AGU membership includes a more diverse range of geoscience fields, such as planetary, atmospheric and ocean science. These data statistically support the general lack of women in certain STEM fields, with the geothermal sector's female representation falling approximately in the middle in terms of proportion of females. Across these geoscience societies analyzed, female participation is growing, and, again, provides a useful trajectory toward estimating future representation.

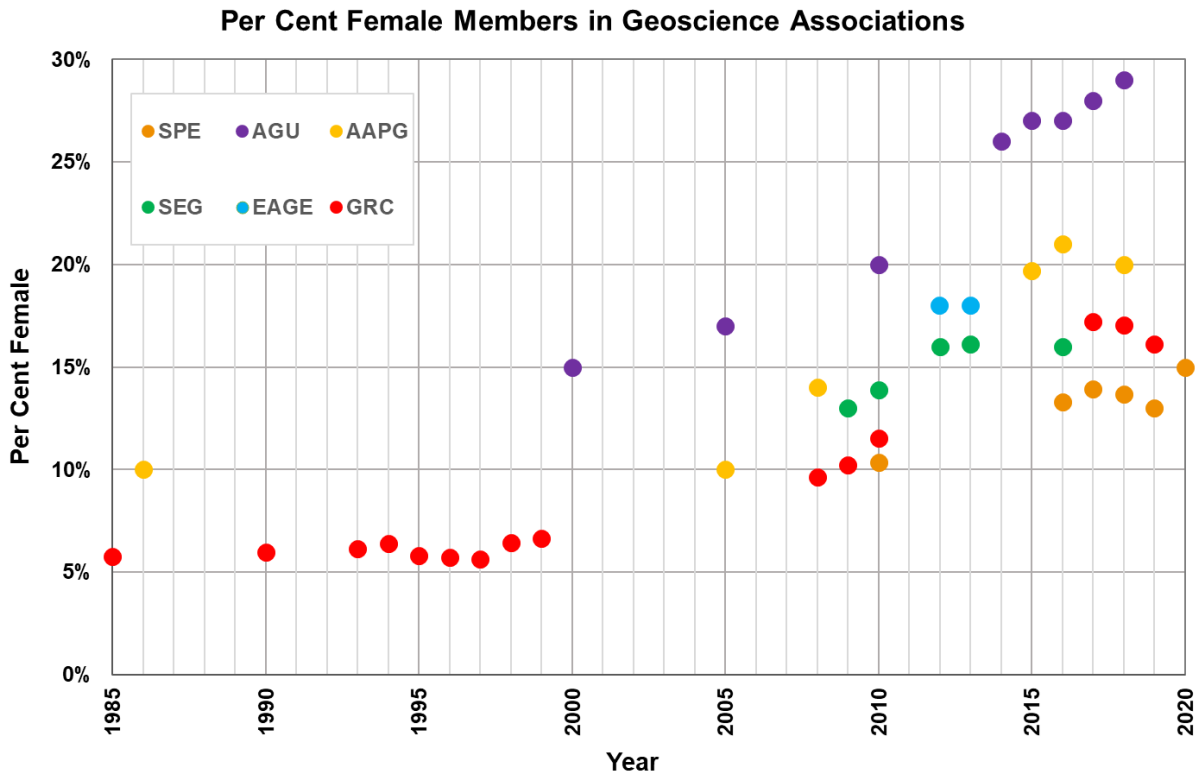

Figure 9: Percentage female membership in professional geoscience associations. SPE = Society of Petroleum Engineers, AGU = American Geophysical Union, AAPG = American Association of Petroleum Geologists, SEG = Society of Exploration Geophysicists, EAGE = European Association of Geoscientists and Engineers, GRC = Geothermal Resources Council

4.2 Female participation in the mining, oil and gas, solar, coal, nuclear, hydro, and wind professions

When compared to other resource industries, the proportion of female professionals in the geothermal sector is similar (Figure 10). It is difficult to make a direct comparison because some of the resource industries do not distinguish the female workforce between professionals and other positions (such as clerical).

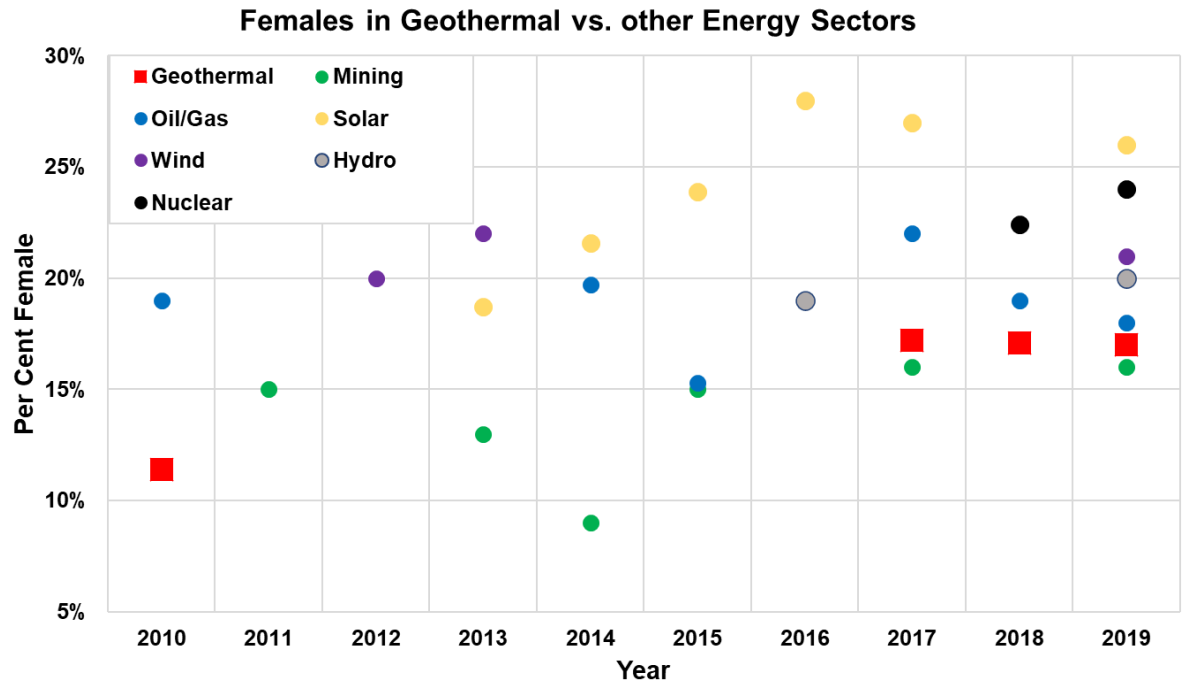

Figure 10: Percentage of females employed in various resource sectors.

5. SUMMARY OF DATA TRENDS

From the various data compiled, we observe a promising trend of increasing proportions of women engaged in the geothermal sector, from less than 10% in 1980, to approaching 20% today: this correlates to an average increase of +2.5% every five years. However, if this slow rate of change continues, we will not achieve parity until beyond the year 2100! The initial data compiled from other organizations and resource sectors outside of geothermal suggest that geothermal is falling behind in terms of gender balance: with the exception of the mining sector (Figure 10) and the Society for Petroleum Engineers (Figure 9), proportionally fewer females are participating in geothermal energy. The reasons for this are complex and reflect multiple societal and cultural factors. However, recognizing the magnitude of the gender disparity in geothermal through review of data such as those presented in this paper is the first step in addressing it. More organizations are demonstrating leadership and implementing new policies and initiatives to support increased gender and cultural diversity; thus, we hope that growth in female participation accelerates in the coming years. One organization that is championing such change is Women in Geothermal (WING).

6. WOMEN IN GEOTHERMAL - USA

Women in Geothermal-USA (WING-USA) was established in 2013 and aims to support the empowerment and development of women in the geothermal sector. Key activities conducted to date include raising the visibility of the gender gap in the geothermal sector in the USA through active participation at the Geothermal Resources Council annual meeting (e.g., having a conference booth, organizing themed lunch-time speakers, inclusive events (yoga and run meet-ups), and on-site activities to stimulate conservation). In 2018, WING-USA defined core values and their associated behaviors that demonstrate these values; they are open, courageous, empowering, caring. Following on from this, WING-USA established the first global WING awards to encourage nomination and recognition of WING members (and our WING-men supporters) who are displaying these core values in their work, and actively supporting the vision of WING.

The data presented in this paper provide a background for WING to assess and create goals for future targets of female representation and participation in the geothermal sector. Increases in the number of females working with the geothermal industry, as well as other STEM fields, in encouraging but is still only a very small portion of each. The newly appointed Global WING team, WING USA, will utilize these data to help build their goals for the next World Geothermal Congress in 2023. We look forward to providing updated data and strive to increase female representation in the geothermal community and in STEM disciplines more broadly.

7. ACKNOWLEDGEMENTS

We thank the companies that participated in the WING-USA survey distributed in June-July 2019: AltaRock Energy, Calpine, Cyrq Energy, Geologica Geothermal Resource Solutions, Geothermal Resource Group, GeothermEx, Ormat Nevada, Inc., and ThermoChem.

In addition, thank you to WING USA and Global teams for the useful discussions, support and information, as well as the GRC office staff for their help and suggestions.

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APPENDIX: DATA TABLES

a. Female authors by conference

Conference	Year	Total authors	Per Cent Female Authors	Per Cent Unknown Authors
GRC	1977	219	2.3	6.8

GRC	1980	492	7.5	3.7
Stanford	1980	104	8.7	1.9
GRC	1984	191	7.3	3.7
Stanford	1985	124	4.8	3.2
GRC	1985	620	4.8	3.9
GRC	1986	179	9.5	2.8
Stanford	1987	64	4.7	7.8
Stanford	1989	122	7.4	4.9
Stanford	1990	86	7.0	4.7
GRC	1990	583	9.6	3.6
Stanford	1995	76	11.8	4.0
WGC	1995	1510	7.8	3.6
GRC	1995	232	6.0	3.5
Stanford	2000	168	9.5	2.4
WGC	2000	1961	9.1	4.2
GRC	2000	353	7.9	4.0
GRC	2003	463	13.2	2.6
Stanford	2005	185	14.6	2.7
WGC	2005	2064	12.4	4.0
GRC	2005	435	12.9	1.4
Stanford	2010	217	14.3	2.3
WGC	2010	3348	16.6	5.3
GRC	2010	717	17.4	2.7
Stanford	2013	760	18.8	3.3
GRC	2013	534	18.9	3.2
GRC	2014	469	20.9	2.6
WGC	2015	4712	18.0	5.5
GRC	2015	523	15.7	1.9
Stanford	2016	893	16.8	4.4
Stanford	2017	730	15.2	3.4
GRC	2017	797	15.2	8.4
Stanford	2018	835	16.1	3.2
GRC	2018	779	15.5	3.7
GRC	2019	424	15.8	2.1
Stanford	2020	609	16.3	4.6
WGC	2020	9974	22.3	5.7

b. Female members of GRC

Year	Total Members	Per Cent Women Members	Per Cent Unknown
1985	1044	5.75	2.01
1990	1075	5.95	1.02
1993	928	6.14	0.86

1994	845	6.39	0.36
1995	825	5.82	0.24
1996	908	5.73	2.09
1997	783	5.62	0.13
1998	748	6.42	0.27
1999	721	6.66	0.28
2008	1016	9.65	0.98
2009	1200	10.20	2.04
2010	1222	11.54	2.05
2017	790	17.22	1.01
2018	827	17.05	2.42
2019	1177	16.10	2.10